BUDDY CARE MATE

Alexa Plotkin & Shrika Eddula

WEEK 1

06/05/23 - 06/12/2023

GCS VS FOUR SCORE

GCS DRAWBACKS

- GCS does not examine the cranial nerve nor determine If patient is “locked-in”
- Intubated patient that can communicate needs will score 1 for verbal response
- GCS is numerically skewed towards motor response

FOUR SCORE BENEFITS

- More comprehensive means of assessing comatose patients
- Takes into account brainstem reflexes
- Does not assess verbal response for a holistic approach
- Takes into account whether the patient is intubated

EYE RESPONSE

FOUR scale:

- E4 = eyelids open or opened, tracking, or blinking to command
- E3 = eyelids open but not tracking
- E2 = eyelids closed but open to loud voice
- E1 = eyelids closed but open to pain
- E0 = eyelids remain closed with pain.

Process:

- Use traditional eye tracking software to test for eyes opening, tracking, and blinking
- Include a beam of light and assess whether patient can trace it
  - programmable motor to rotate beam of light appropriately
- Include a speaker to instruct patient to open their eyes
- Include an air jet to simulate a pain response

IR emitter

Beam of Light

Standard Camera Module

Motor to Pivot Light

Micro 12V DC Air Pump

Retractable Extension for Air Pump/Light

MOTOR RESPONSE

FOUR Score

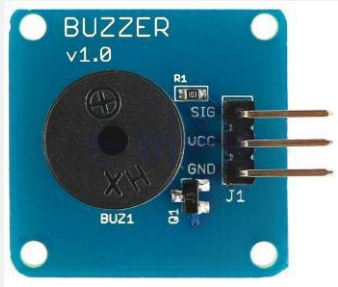
- M4 = thumbs-up, fist, or peace sign;
- M3 = localizing to pain;
- M2 = flexion response to pain;
- M1 = extension response to pain;
- M0 = no response to pain or generalized myoclonus status

Process:

- Can patient translate cognitive understanding to motor response?
- Patient asked to make a peace sign, victory sign, fist, etc
- External stimuli by puff of air and determine response
- Determine if patient is moving: background subtraction for motion detection https://www.interscience.in/ijess/vol2/iss3/7/

Standard Camera Module

Micro 12V DC Air Pump



Speaker Module

Retractable Extension for Air Pump/Light

BRAINSTEM RESPONSE

FOUR scale:

- B4 = pupil and corneal reflexes present
- B3 = one pupil wide and fixed
- B2 = pupil or corneal reflexes absent
- B1 = pupil and corneal reflexes absent
- B0 = absent pupil, corneal, and cough reflex

Process:

- Shine a beam of light near patient's eye to induce pupil reflex
- Trigger air puff near patient's eye to induce corneal reflex
- Use software to measure pupil reflex with IR camera

Alternative option: gait analysis

- Overly cautious gait correlated to cranial nerve damage
- Use computer vision algorithm to determine deviations from standard gait
- ML Algo: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9612353/

Beam of Light

Motor to Pivot Light

Micro 12V DC Air Pump

Retractable Extension for Air Pump/Light

RESPIRATORY PATTERN

FOUR Score

- R4 = not intubated, regular breathing pattern
- R3 = not intubated, Cheyne-Stokes breathing pattern [cyclic fast and slow breathing]
- R2 = not intubated, irregular breathing
- R1 = breathes above ventilatory rate
- R0 = breathes at ventilator rate or apnea

Process:

- Respiration Rate: monitor breathing pattern
  - Use temperature changes in nostril and mouth area to assess
  - Infrared based remote monitoring:
- Pulse from head motions in video:
  - Heart rate and beat lengths extracted from my measuring subtle head motion caused by Newtonian reaction to influx of blood at each beat

Infrared Camera Module

Standard Camera Module

Thermal Imaging Camera

QUESTIONS AND FUTURE CONSIDERATIONS

- Are the deliverables for the design portion in terms of a functioning prototype (etc arduino) or that if components outlined in schematic and software development were purchased, the device would be fully functional in the field?
- TinyML approach? All data processing done on device itself?
- Must we assume that this is a situation where the patient is alone and there is no buddy to invoke external stimuli? Yes
- Can the UAV produce any stimuli (beam of light, noise, air puff)? Yes but on device
- Would we need to account for nighttime (special camera)? Would be nice, use thermal camera
- Would we need to account for inconspicuousness?
- TENTATIVE SUMMER '23 OUTLINE.DOCX
  - POTENTIAL BOSTON TRIP?

WEEK 2

06/12/23 - 06/19/2023

GLASGOW COMA SCALE

EYE RESPONSE

- **4**: Spontaneous--open with blinking at baseline
- **3**: To verbal stimuli, command, speech
- **2**: To pain only (not applied to face)
- **1**: No response

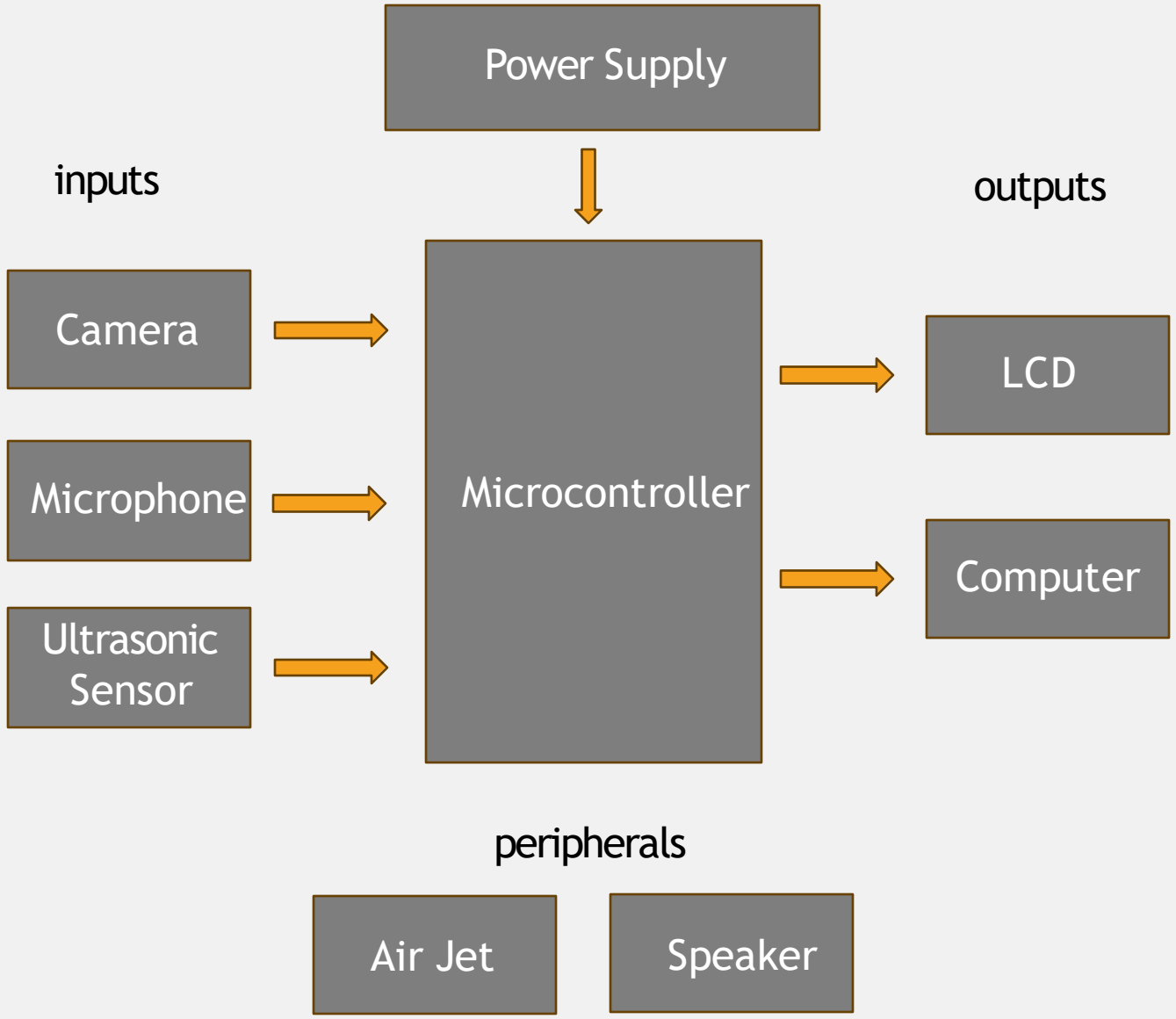
VERBAL RESPONSE

- **5**: Oriented
- **4**: Confused conversation, but able to answer questions
- **3**: Inappropriate words
- **2**: Incomprehensible speech
- **1**: No response

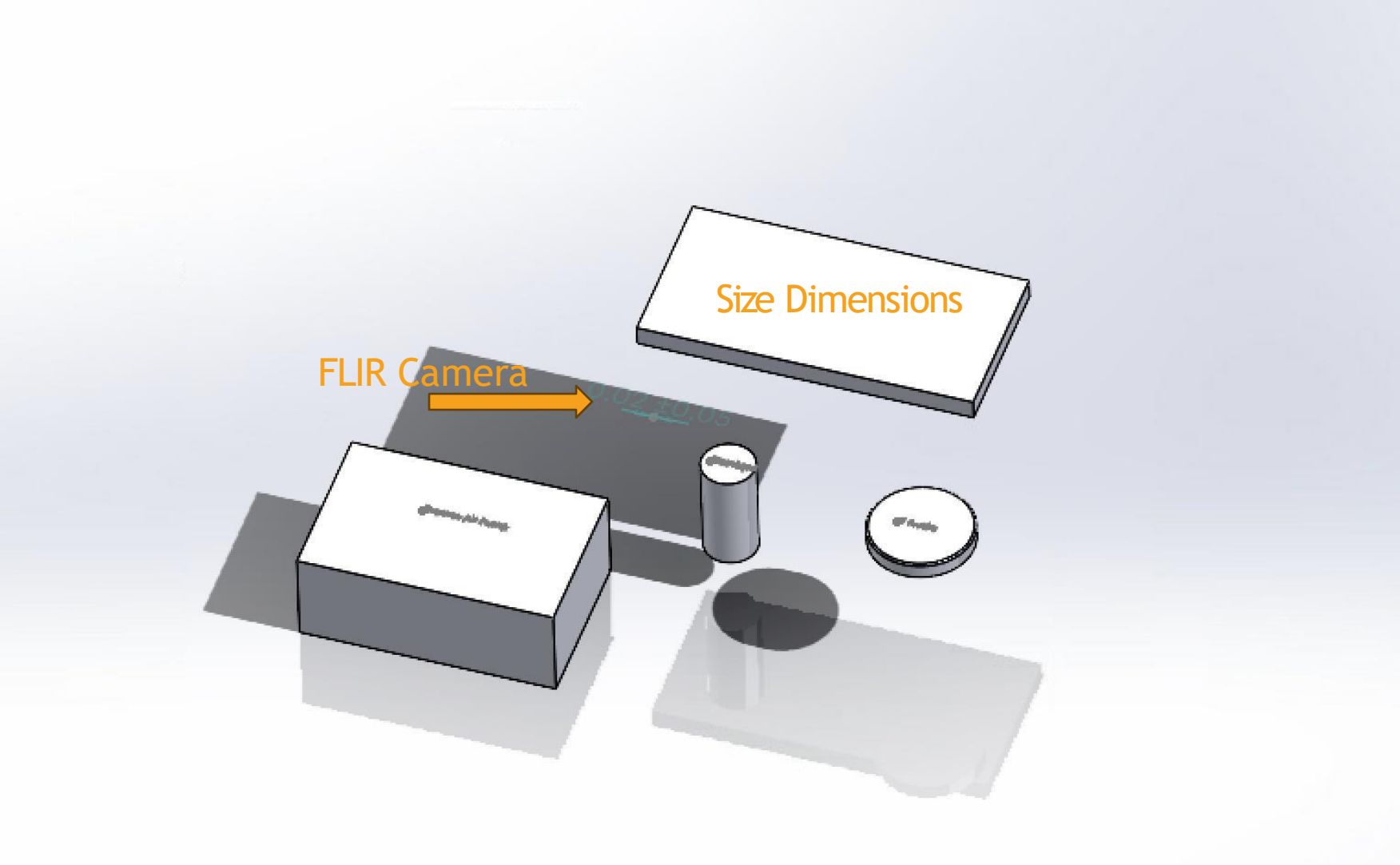
MOTOR RESPONSE

- **6**: Obeys commands for movement 6 points
- **5**: Purposeful movement to painful stimulus
- **4**: Withdraws in response to pain
- **3**: Flexion in response to pain (decorticate posturing)
- **2**: Extension response in response to pain (decerebrate posturing)
- **1**: No response

BLOCK DIAGRAM



CAD MODEL



EYE RESPONSE

Glasgow Coma Scale

- **4:** Spontaneous--open with blinking at baseline
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Software

- Python package to detect eye blinks: https://pyimagesearch.com/2017/04/24/eye-blink-detection-opencv-python-dlib/

Process

- Under what circumstances/stimuli does patent open their eyes
- Use traditional eye tracking software to test for eyes opening and blinking
- Include a speaker to instruct patient to open their eyes
- Include an air jet to simulate a pain response

Standard Camera Module

Micro 12V DC Air Pump

Retractable Extension for Air Pump/Light

VERBAL RESPONSE

Glasgow Coma Scale

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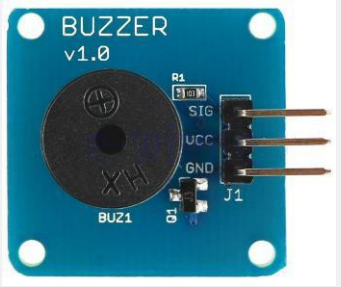
Software

- Speech to text software: Google Cloud Speech-to-Text
- Determine score: OpenAI's GPT-4

Process

- Ask patient question
- EX: Patient was asked what year it was. It is currently 1967 but the patient responded with "it it it is my time". Patient should be given score of 4



Speaker Module

Microphone

Micro 12V DC Air Pump

Retractable Extension for Air Pump/Light

MOTOR RESPONSE

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Software

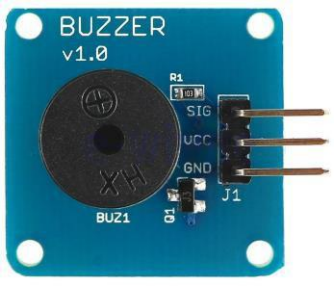
- Pose Detection Software/Models
  - https://developers.google.com/ml-kit/vision/pose-detection
  - https://github.com/CMU-Perceptual-Computing-Lab/openpose

Process

- Under what circumstances/stimuli does patient move
- Patient asked to make a peace sign, victory sign, fist, etc
- External stimuli by puff of air and determine response
- Determine how the pose position markings change in response to stimuli

Standard Camera Module

Micro 12V DC Air Pump



Speaker Module

Retractable Extension for Air Pump/Light

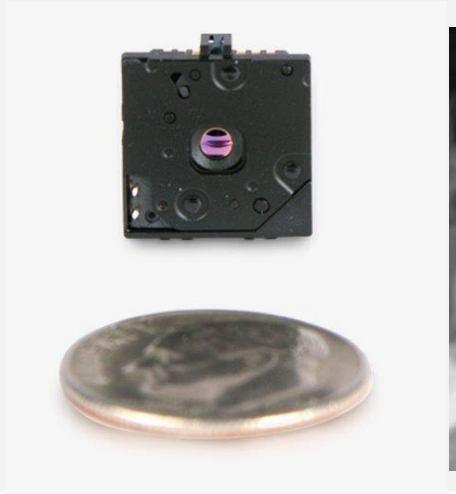
AIR JET

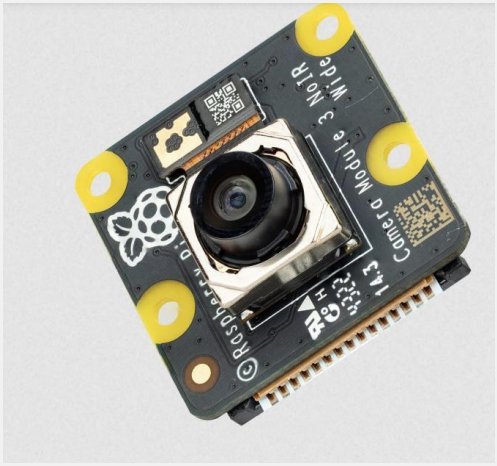
Name	**Fanttik** X8 Portable Tire Inflator	**VIAIR** 88P Portable Compressor
Dimensions (l x w x h cm)	14 x 8.5 x 4.3	24 x 8.1 x 14
Weight (lb)	1.13	4.5
Electric	Emailed to ask; 20Ah	12V; 20A
Max Air Pressure (PSI)	150	120
Comments	Battery operated	Corded

SPEAKER

Name	**Wet Sounds** RECON 5-S	**Garmin** Fusion	**DJI** Mavic 3 Enterprise Series Speaker
Dimensions (l x w x h cm)			11,4x 8.2 x 5.5
Weight (lb)	4		.18
Electric	100W (peak)		3W
Max volume (1W/m db)	89		110 (?checking)
Comments	Marine Speaker	Marine Speaker	Drone speaker

CAMERA

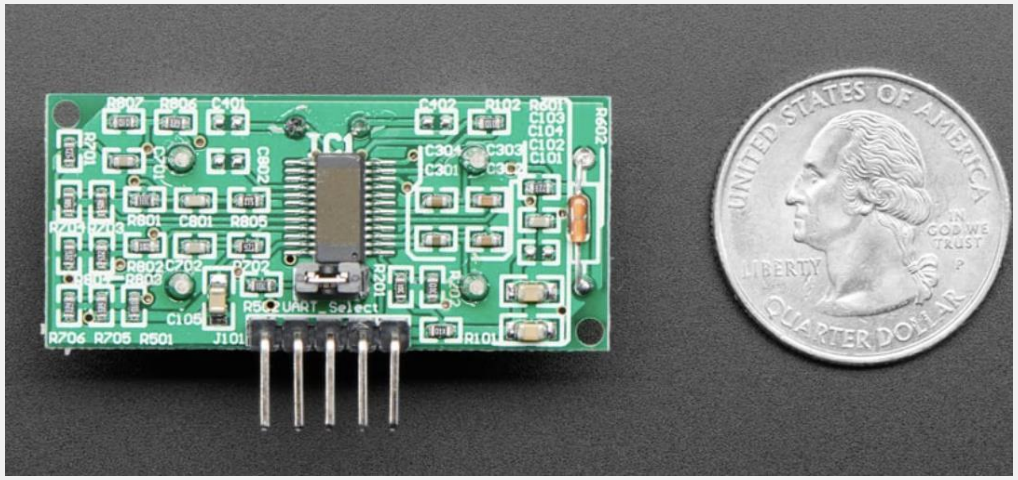




Name	Teledyne FLIR Lepton	Raspberry Pi Camera Module
Dimensions (l x w x h cm)	1.05 x 1.27 x .714	2.5 x 2.38 x 1.13
Weight (lb)	.001	Not Given
Electric	2.8V input; 150mW consumption	Raspberry Pi
Resolution (pixels)	160 x 120	4608 x 2592
Frames per second	8.7	60
Environmental Comments	Withstand shock of 1500g/.4ms; Integral solar protection; operates -10°C - +80°C	N/A

ULTRASONIC SENSOR

Name	US-100 Ultrasonic Sonar Distance Sensor
Dimensions (l x w x h cm)	
Weight (lb)	.019
Electric	2.4-5V input
Detection Distance (cm)	2-450 (accurate to .3)



QUESTIONS AND FUTURE CONSIDERATIONS

- Microphone? How can we pick up audio accurately? Multiple mics and background noise cancellation software? Extended mic?
- Are we looking for one uniform battery or can each device have its own battery?
- Are we going to put everything in a protective covering (don't need marine grade speakers)
- Shrika and I think that a potential Boston trip might be beneficial for us especially so that we can see the individual parts (such as the air jet) programmed with the computer. We are going to speak to George about it tomorrow but what are your thoughts?

WEEK 3

06/19/23 - 06/26/2023

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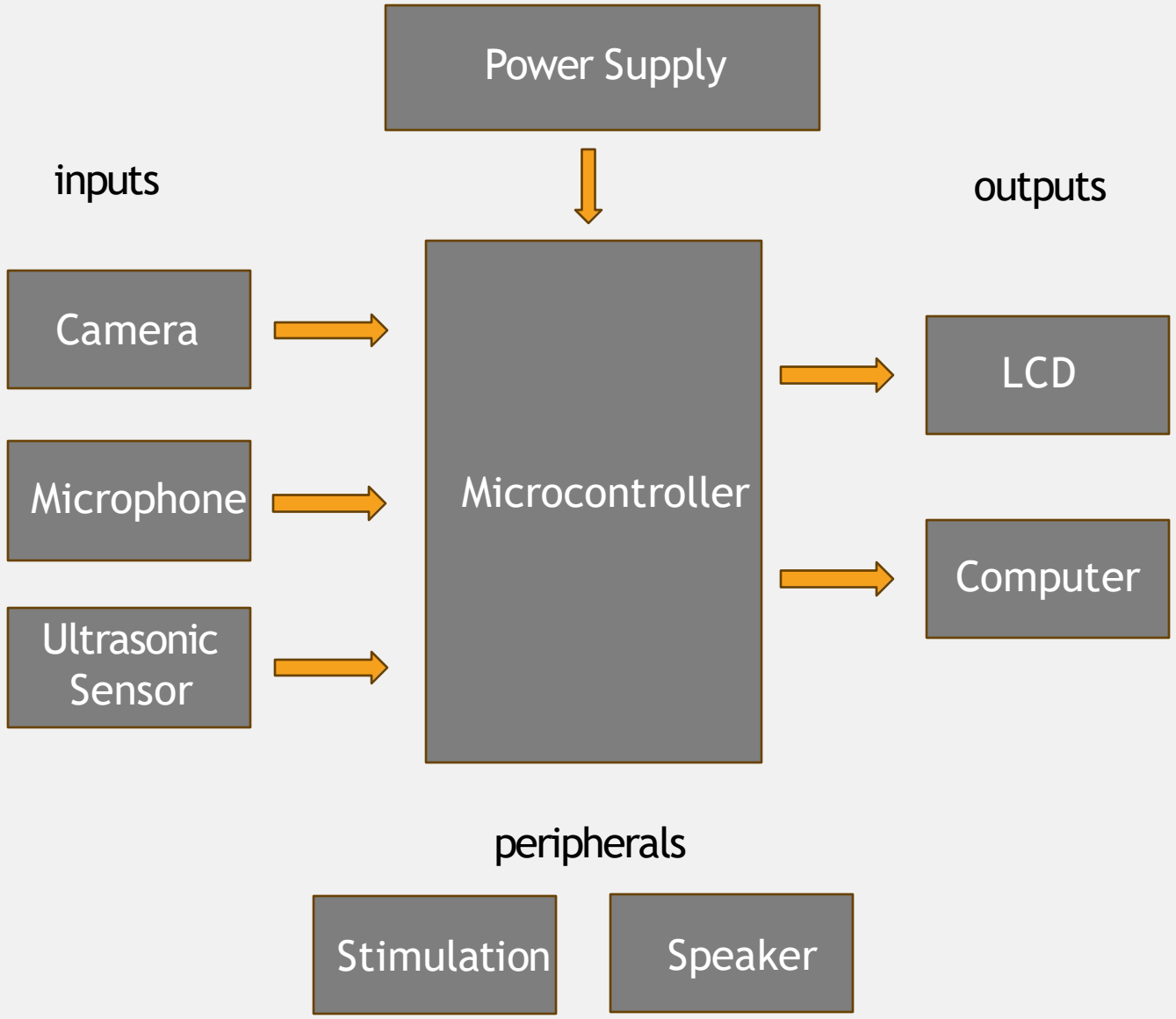

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Hardware

- Camera
- Pain stimulation device

Process

- Under what circumstances/stimuli does patent open their eyes
- Use traditional eye tracking software to test for eyes opening and blinking
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Process

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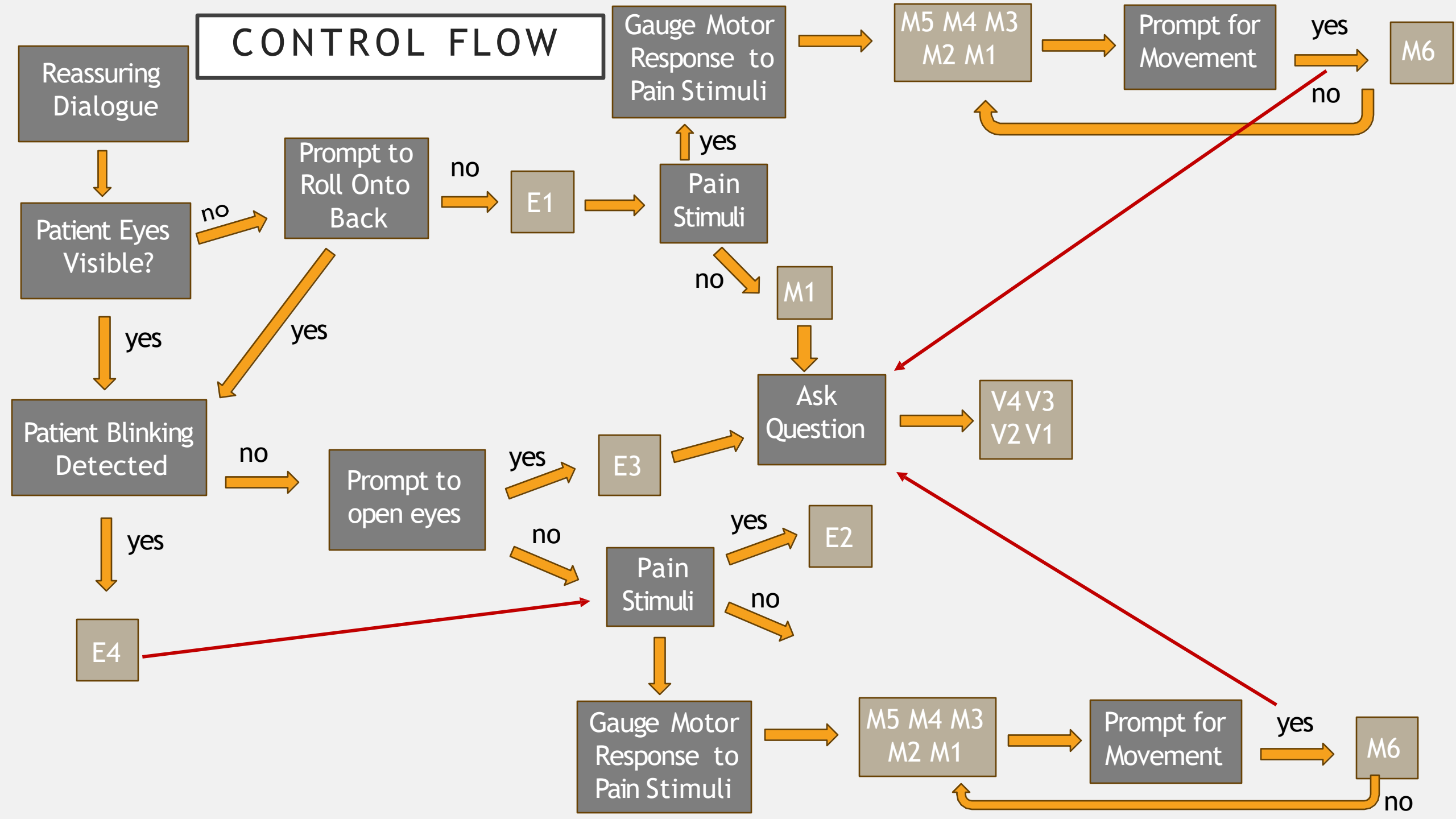
  - https://developers.google.com/ml-kit/vision/pose-detection
  - https://github.com/CMU-Perceptual-Computing-Lab/openpose

Hardware

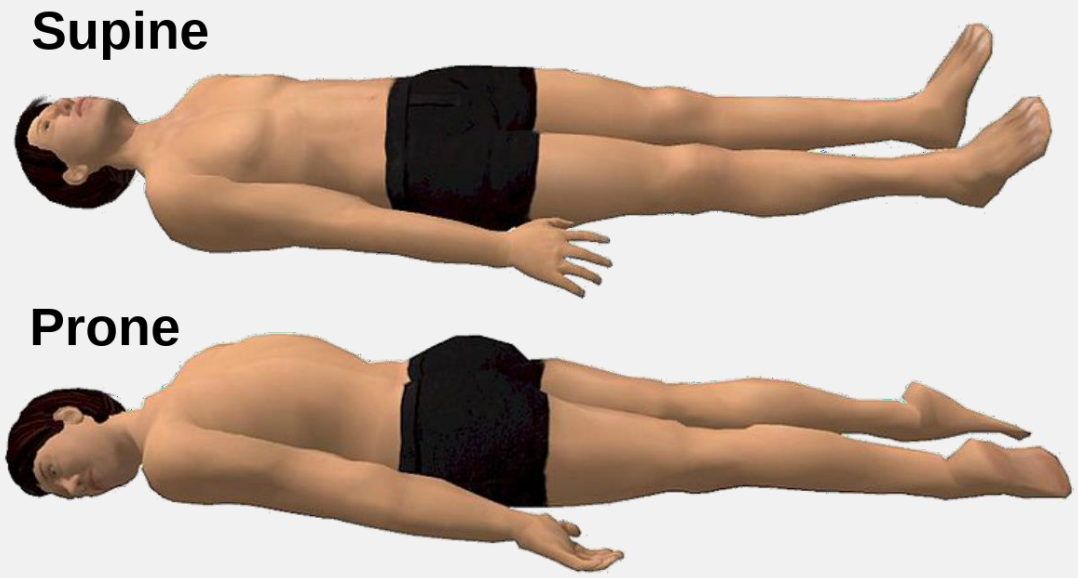
- Camera
- Ultrasonic distance sensor
- Pain stimulation device

Process

- Under what circumstances/stimuli does patient move
- Patient asked to make a peace sign, victory sign, fist, etc
- External stimuli by puff of air and determine response
- Determine how the pose position markings change in response to stimuli


CONTROL FLOW
Reassuring Dialogue
Patient Eyes Visible?
no
yes
Prompt to Roll Onto Back
no
yes
E1
Gauge Motor Response to Pain Stimuli
yes
Pain Stimuli
no
M1
M5 M4 M3 M2 M1
Prompt for Movement
yes
no
M6
Patient Blinking Detected
no
yes
Prompt to open eyes
yes
E3
Ask Question
V4 V3 V2 V1
E4
Pain Stimuli
yes
E2
no
Gauge Motor Response to Pain Stimuli
M5 M4 M3 M2 M1
Prompt for Movement
yes
M6
no

ERROR SOURCES: PRONE POSITION



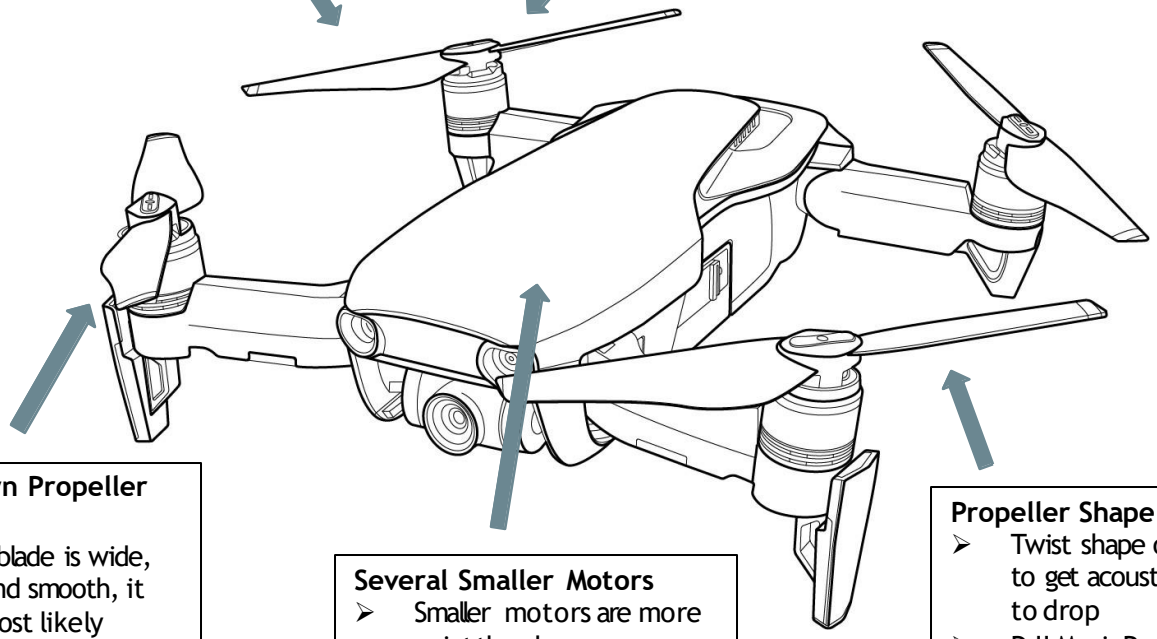
Eye	Verbal	Motor
➢ Patient injury could prevent movement into supine position ➢ Patient Eye response might NOT be impaired but will be unable to perform accurate assessment ➢ Default to E1	➢ Patient speech muffed from being in prone position ➢ Audio quality might not be best, impairs accuracy ➢ Results in lower V score, or default to V1	➢ No issues with motor response

DRONE NOISE CANCELLATION

- Several different types of low noise propellers on the market
- Dotteral noise reduction shrouds capable of reducing up to 10 decibels
- Northwest UAV has such a propeller that produces little noise and resembles a bat wing
- Sony Patent: "speakers equipped with the drones are capable of creating audio signals that cancel the processed ambient noise resulting in virtual noise cancellation boundary"

Large Slower Propellers
- Displace more air per turn
- Do not need to rotate as fast to keep drone up
- Less noise

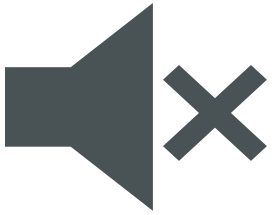
Noise Reduction Shrouds
- Reduce noise caused by propeller blades hit parts of drone
- Use nanofiber sound dampening materials to absorb noise



Sand Down Propeller Surface
- If the blade is wide, flat, and smooth, it will most likely produce little to no noise

Several Smaller Motors
- Smaller motors are more quiet than larger ones
- Several smaller motors more noise efficient

Propeller Shape
- Twist shape of propeller to get acoustic signature to drop
- DJI Mavic Pro incorporated the "raked wingtip" to reduce drone noise



Sony Patent: "speakers equipped with the drones are capable of creating audio signals that cancel the processed ambient noise resulting in virtual noise cancellation boundary"

Drone itself can not cancel out its own noise through

Based off network of drones that work together

Get this to work on one drone?

GoPro Patent: "audio signal filter that utilizes operational condition input parameters from components of the vehicle"

Parameters act as a baseline of noise (i.e. vibrational and air noise) from the audio signal

Audio signal filter combines the analysis of vehicle component operational conditions and distances of the components from the microphone to filter the noise information from the operation of the drone

NOISE CANCELLATION SOFTWARE

AIR JET PAIN STIMULATION

Name	**Fanttik** X8 Portable Tire Inflator	**VIAIR** 88P Portable Compressor
Dimensions (l x w x h cm)	14 x 8.5 x 4.3	24 x 8.1 x 14
Weight (lb)	1.13	4.5
Electric	Emailed to ask; 20Ah	12V; 20A
Max Air Pressure (PSI)	150	120
Comments	Battery operated	Corded

NOTES ON LASER STIMULATION

PAIN STIMULATION

- Generates pain prick simulation by rapidly increasing pulses of heat
  - With pulse durations of 300ms/+, temperature of the skin has to reach 46°-48°C to induce a prickling pain sensation
- Time interval between applied pulses must be more than 3s
- Skin absorption depends on skin pigment below 1080nm
- Different wavelengths require different stimulation times
- Larger beam diameter spread the Energy in a more safe manner over the skin

TYPES OF LASERS

- CO2 laser:
  - Utilizes a tube filled with CO2 gas; very large
  - Wavelength of 1060nm
  - Used in medical procedures but too large for our use
- Diode laser:
  - Utilizes a semiconductor; varied in size
  - Varied wavelengths
  - Patent produced in 2008 that reviews the use in pain stimulation
  - Could not find an emittance diameter as wide as experiments
- Visible Argon laser:
  - Utilizes a tube filled with Argon gas; very large
  - Wavelength of 400-500nm
  - Used for pain research but too large for our use
- Yttrium Aluminum Garnet (YAG) laser:
  - Utilizes a tube with a crystal
  - Wavelength of 2000
  - Used in laser eye surgery; had difficulty finding available products

LOOKED INTO THIS THE PAST WEEK

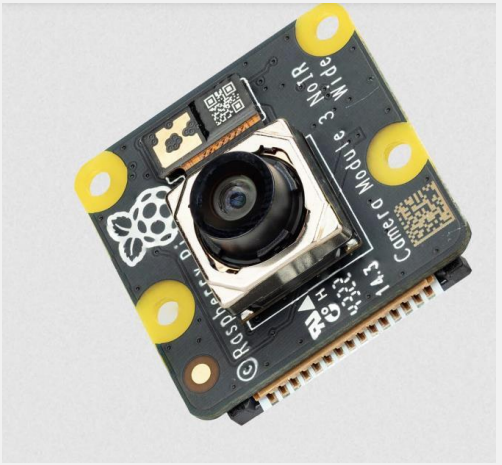
WILL LOOK INTO THIS THE UPCOMING WEEK

DIODE LASER PAIN STIMULATION

LOOKED INTO THIS THE PAST WEEK

Name	**Aerodiode** Grating Stabilizer Laser Diode	**Excelitas** LQPGAU1S03	**Laser Diode Source** FB-M1060-2000TO3
Dimensions (l x w x h cm)	.61 x 1.7 x 3.4	.12 x .12 x 3.5	3.8 x 3.8 x 2.5
Weight (lb)	?	?	?
Output Power (W)	10	24	2
Wavelength (nm)	980	905	1060
Emitting Area (µm)	?	37.5 x 15	100x1

CAMERA

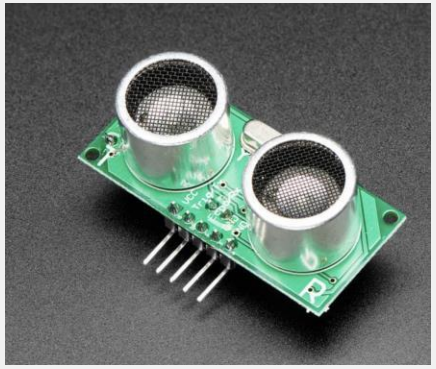


Name	**Teledyne FLIR** Lepton	**Raspberry Pi** Camera Module
Dimensions (l x w x h cm)	1.05 x 1.27 x .714	2.5 x 2.38 x 1.13
Weight (lb)	.001	Not Given
Electric	2.8V input; 150mW consumption	Raspberry Pi
Resolution (pixels)	160 x 120	4608 x 2592
Frames per second	8.7	60
Environmental Comments	Withstand shock of 1500g/.4ms; Integral solar protection; operate -10°C - +80°C	N/A

SPEAKER

Name	CUIdevices CMS-15113-078L100
Dimensions (l x w x h cm)	1.1 x 1.5 x .3
Weight (lb)	.003
Electric	1W input
Sound (db)	94

ULTRASONIC SENSOR



Name	**ADAfruit** US-100 Ultrasonic Distance Sensor	**CUIDevice** CUSA-TR60-02-2000-TH67
Dimensions (l x w x h cm)	4.5 x 2 x 2	1 x 1 x 1
Weight (lb)	.019	.001
Electric	2.4-5V input	?
Detection Distance (m)	.02-4.5 (accurate to .003)	.5 - 2
Ingress Protection Rating	N/A	IP67
Response Time (ms)	N/A	1.8

QUESTIONS AND FUTURE CONSIDERATIONS

- Can we make the box stand 8 x 1 x 16 instead of 8 x 16 x 1 (cm)?
- Should we consider lasers that require replacement gasses/crystals?
- Should weight/cost be a consideration?
- Uncovered microphone portion?

WEEK 4

06/26/23 - 07/03/2023

LASER SAFETY

- Class 2 lasers:
  - Includes visible light lasers operating below 1000mW
  - Dangers:
    - Considered safe as long as you do not intentionally stare at it
- Class 3b lasers:
  - Includes visible light lasers operate from 10000-5000mW and IR lasers operating from 0-5000mW
  - Dangers:
  - Considered hazardous if exceeding maximum permissible exposure (MPE) limit
    - MPE: Minimum irradiance or radiant exposure that may be incident upon the eye or skin without causing biological damage
    - Pulsed lasers cannot exceed 30 mJ

Wavelength	Visible	Near IR	IR
MPE on eyes for 1μs-10s (J/cm^2)	10^-3	10^-3	1
MPE on skin for 1μs-10s (J/cm^2)	1	1	.5

OUR USE OF LASER PAIN STIMULATION

- Fluence (J/cm^2) is a unit that encompasses wattage*seconds/area emitted
  - There is varying information on what fluence induces a pain stimulus
- All laser stimulated pain experiments performed on humans have emittance diameters between .5-6mm
  - With the size restrictions, we can only utilize laser diodes with an emittance diameter near150 μm
- However, even with this smaller emittance diameter, we can reach the necessary fluence by:
  - Utilizing a beam expander to make the emittance diameter on the order of 1mm and using a higher wattage
    - Benefits: Would correspond to beam size used in pain stimuli experiments
    - Risks: would likely bump the laser classification into Class 3b and above the MPE
  - Utilizing the smaller emittance diameter and a smaller wattage to obtain the necessary pain stimulating fluence
    - Benefits: eye safe, fits the size restriction
    - Risks: concentrates power into a very small area not readily researched likely due to the higher risk for burn lesions

OUR USE OF LASER PAIN STIMULATION

Potential solution	IR Laser	Near IR Laser	Visible Light Laser
Wavelength (nm)	1550	900-1000	400-500
Pain Stimulation Fluence (J/cm^2)	.3	1.4	.02
Safety Fluence	Below MPE level	Above MPE level	Below MPE Level
Comments	Possible to purchase but would need to have emittance area of 50 μm	Important to note that this is the only laser pain stimulating article that we found that utilizes a diode laser; Possible to purchase but would need to have emittance area of 50 μm	Could not locate a diode laser capable of pulsing at this wavelength; likely used a YAG Q switched laser

ALTERNATE PAIN STIMULATION

- Trapdoor that releases a tethered weight that can drop onto the patient; will be retrieved with gear and motor
  - Questions moving forward:
    - What tethered material to use?
    - What weight to use?
    - Should we standardize the length of the tether to reach the patient or recalculate each time?
  - Need to gather information on if this has been previously done in experiments
  - Advantages: requires small components
  - Disadvantages: cannot control environmental effects that influence where the weight might land;

DOTTEREL MEETING

- Who is Dotterel?
  - The only company producing audio UAV attachments (to our knowledge)
  - New Zealand company, their prototype is based on the American DJI Matrice 20 drone
  - https://www.dotterel.com/technology/aerial-audio
- What did we talk about?
  - The smallest microphone attachment that they have is 1.25" high x 5.11" long x 4.05" wide and can operate from 1 mile away
    - Although the smaller distance of 1 meter makes the development of a product for us more likely, it would not be feasible before 12 months
  - The noise reduction software that is capable of picking up voices functions by differentiating sound from in front of the shotgun microphone from what is behind it
    - Consequence of this is that the shotgun microphone must be placed in front of and extended from the drone
  - Suggested inefficiency in not using utilizing universal components found in drones (such as a 12V power supply, Bluetooth camera, Bluetooth speaker)
- What should we do moving forward?
  - Since there is no information about a microphone capable of existing on a drone and picking up audio from just 1m, should we move forward with the industry's "best" portable shotgun microphone in combination with standard noise cancellation software?
    - Difficult to know if it will work without testing it

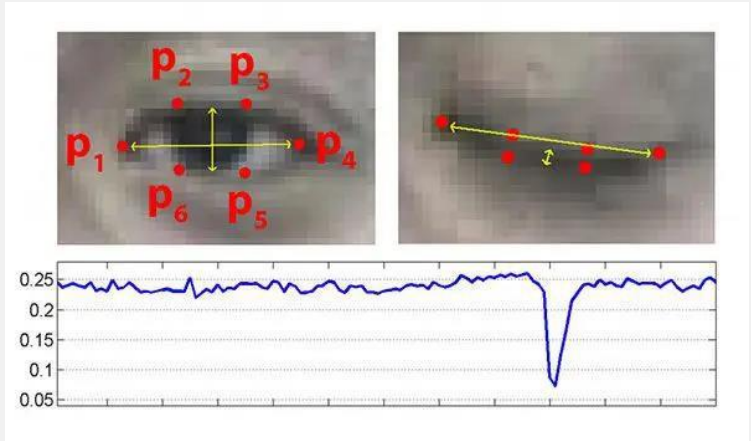
DOTTEREL MEETING

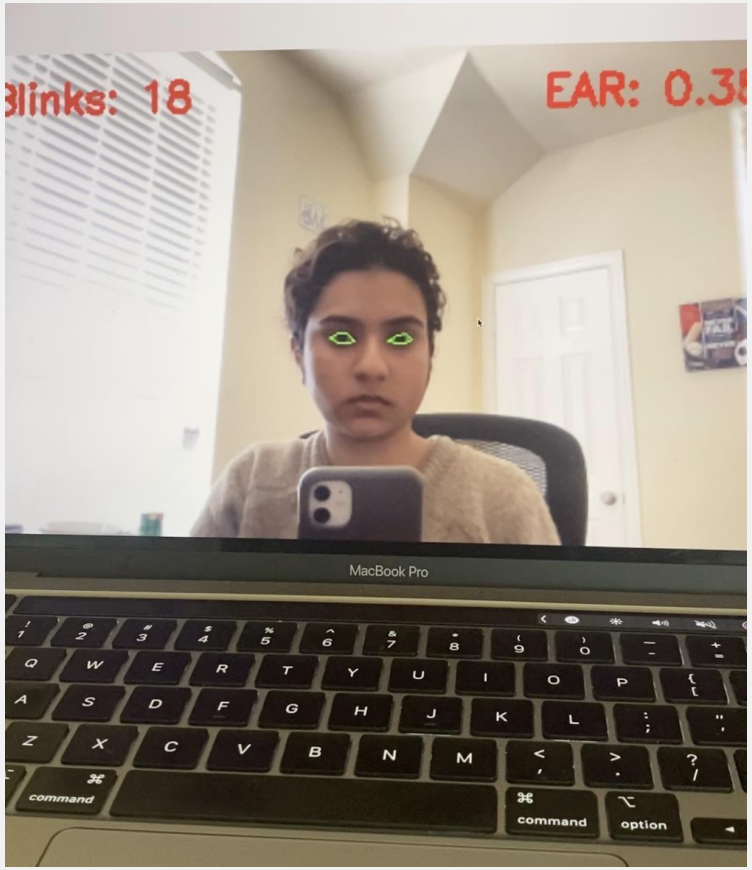
What should we do moving forward?

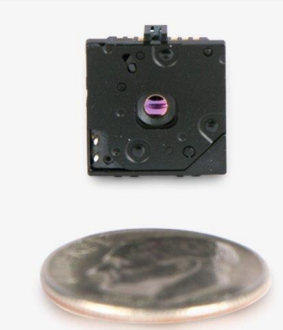
- What other devices will be put on this drone?
- Will they all require a camera/microphone?
  - If so, singular central components that interact through bluetooth?

EYE BLINK DETECTION SOFTWARE

- Confirmed used of the Teledyne FLIR Lepton
  - Built using mathematical measurements for eye aspect ratio
  - Platform: Python OpenCV
  - Eye aspect ratio will go down with blink
  - Can use threading to work with lower fps

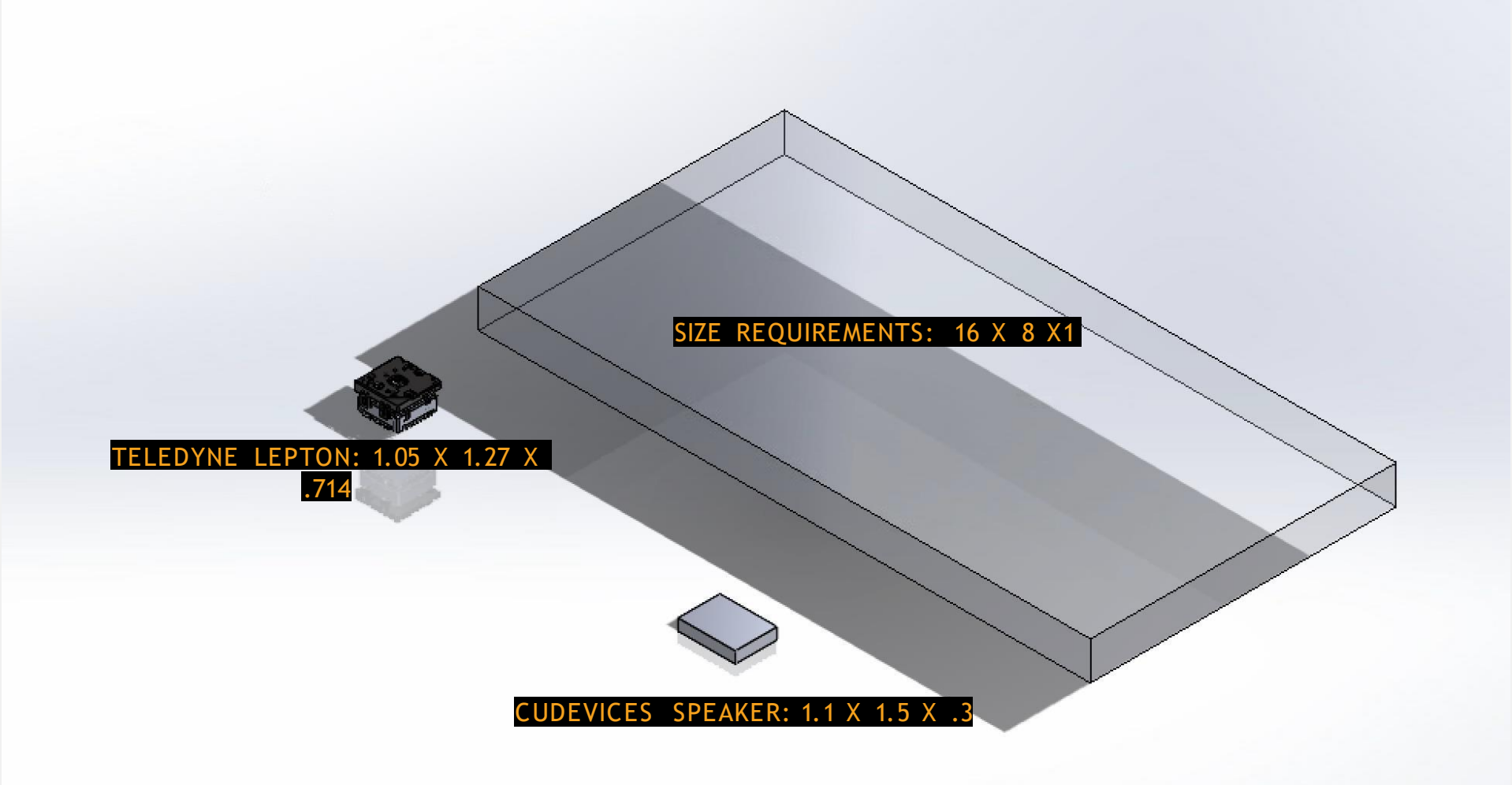






Name	Teledyne FLIR Lepton
Dimensions (l x w x h cm)	1.05 x 1.27 x .714
Weight (lb)	.001
Electric	2.8V input; 150mW consumption
Resolution (pixels)	160 x 120
Frames per second	8.7
Environmental Comments	Withstand shock of 1500g/.4ms; Integral solar protection; operate -10°C - +80°C

MODELING



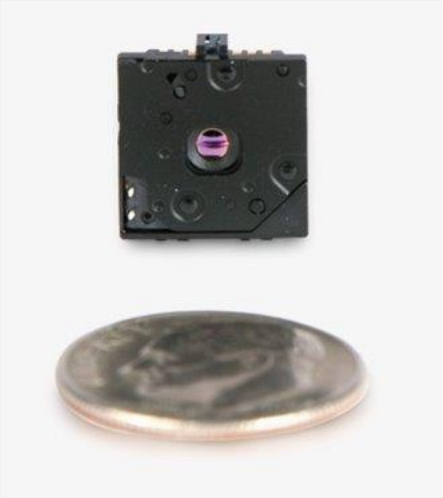
ALL MEASUREMENTS IN CM

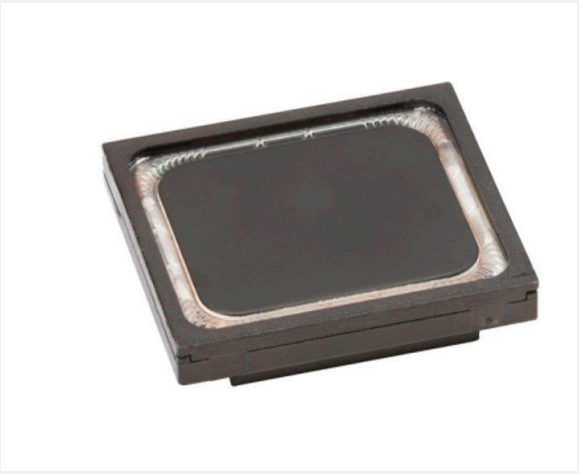
PAIN STIMULATION

Name	**Aerodiode** Grating Stabilizer Laser Diode	**Fanttik** X8 Portable Tire Inflator	Alternative Method
Dimensions (l x w x h cm)	.61 x 1.7 x 3.4	14 x 8.5 x 4.3	N/A
Process	Shine laser at patient's hand to induce pain response	Aim puff of air strong enough at patient's hand to induce pain response	Release tethered weighted object to hit patient's hand to induce pain response; retrieve tethered object with geared motor
Advantages	Significant research on use of lasers as pain stimuli; It is possible to buy lasers that fit within size restrictions	No possible eye injury	Can be customized to fit within size restrictions; No possible eye injury
Disadvantages	No research done on pain from lasers of our size restriction; possible eye hazard and burn lesions	Minimal research done on air pain response; only devices with high enough pressure to induce response are tire inflators, which are too large	No research done about this process; many factors to consider (what type of tether and weight to use)

PROGRESS TO DATE

HARDWARE DEVICES





Name	Laser Components 155G1S02X	Teledyne FLIR Lepton	CUIdevices CMS-15113-078L100
Dimensions (l x w x h cm)	1.7 x .5 x .5	1.05 x 1.27 x .714	1.1 x 1.5 x .3
Weight (lb)	N/A	.001	.003
Other data	Wavelength of 1550nm	8.7 frames per second	94 db

QUESTIONS AND FUTURE CONSIDERATIONS

- Can we stimulate a smaller than suggested laser emittance area in order to have an eye safe laser?
- Can we have a pain stimuli that has a refillable component (water, pellet, etc.)?
- Can the microphone be uncovered from the box dimensions?

WEEK 5-6: DEMO DAY

07/03/23 - 07/17/2023

X-FORCE

NATIONAL SECURITY INNOVATION NETWORK

Buddy Care Mate

United States Army Research Institute of Environmental Medicine

Alexa Plotkin & Shrika Eddula
Gary Zientara, Ph.D.

GOAL

To design a smartphone sized drone attachment that can remotely assess a wounded Warfighter's state of consciousness on the battlefield as per the Glasgow Coma Scale.

GLASGOW COMA SCALE

EYE RESPONSE

- **4**: Spontaneous--open with blinking at baseline
- **3**: To verbal stimuli, command, speech
- **2**: To pain only (not applied to face)
- **1**: No response

VERBAL RESPONSE

- **5**: Oriented
- **4**: Confused conversation, but able to answer questions
- **3**: Inappropriate words
- **2**: Incomprehensible speech
- **1**: No response

MOTOR RESPONSE

- **6**: Obeys commands for movement 6 points
- **5**: Purposeful movement to painful stimulus
- **4**: Withdraws in response to pain
- **3**: Flexion in response to pain (decorticate posturing)
- **2**: Extension response in response to pain (decerebrate posturing)
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EYE RESPONSE

Glasgow Coma Scale

- **4**: Spontaneous--open with blinking at baseline
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Software

- Python package to detect eye blinks: https://pyimagesearch.com/2017/04/24/eye-blink-detection-opencv-python-dlib/

Hardware

- Camera
- Speaker
- Laser

Process

- Under what circumstances/stimuli does patent open their eyes
- Use traditional eye tracking software to test for eyes opening and blinking
- Include a speaker to instruct patient to open their eyes
- Include a laser to simulate a pain response

Teledyne Camera

Speaker

Laser

EYE BLINK DETECTION ALGORITHM

- Built using mathematical measurements for eye aspect ratio
- Platform: Python OpenCV
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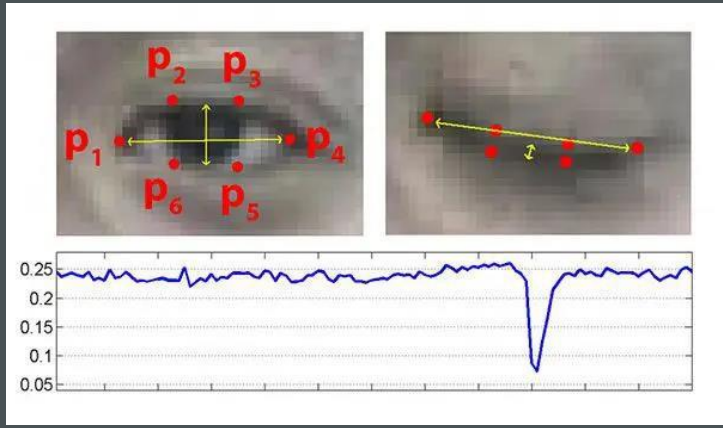

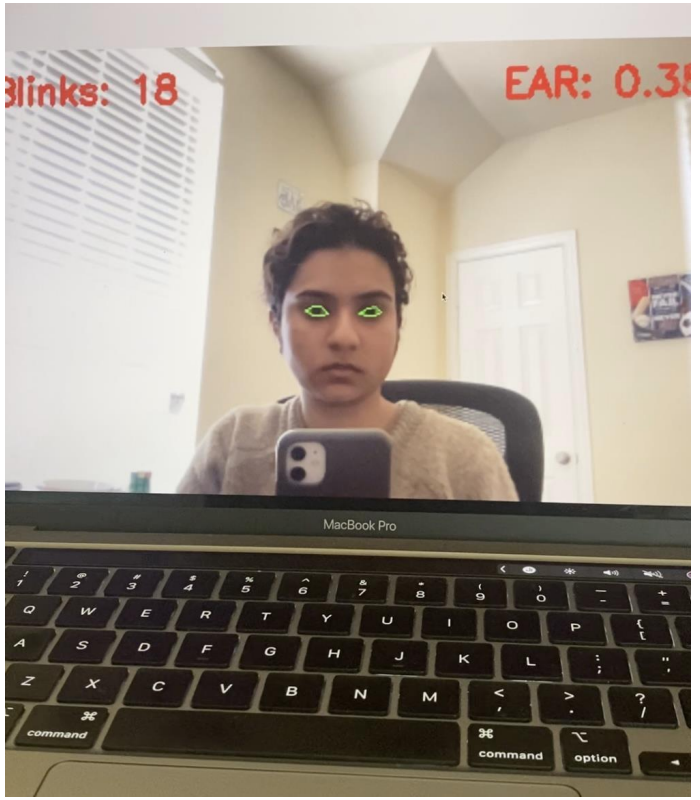

VERBAL RESPONSE

Glasgow Coma Scale

- 5: Oriented
- 4: Confused conversation, but able to answer questions
- 3: Inappropriate words
- 2: Incomprehensible speech
- 1: No response

Software

- Speech to text software: Google Cloud Speech-to-Text
- Determine score: OpenAI's GPT-4

Hardware

- Speaker
- Microphone

Process

- Ask patient question
- EX: Patient was asked what year it was. It is currently 1967 but the patient responded with "it it it is my time". Patient should be given score of 4

Speaker

MOTOR RESPONSE

Glasgow Coma Scale

- 6: Obeys commands for movement 6 points
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- Pose Detection Software/Models
  - https://developers.google.com/ml-kit/vision/pose-detection
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Hardware

- Camera
- Speaker
- Laser

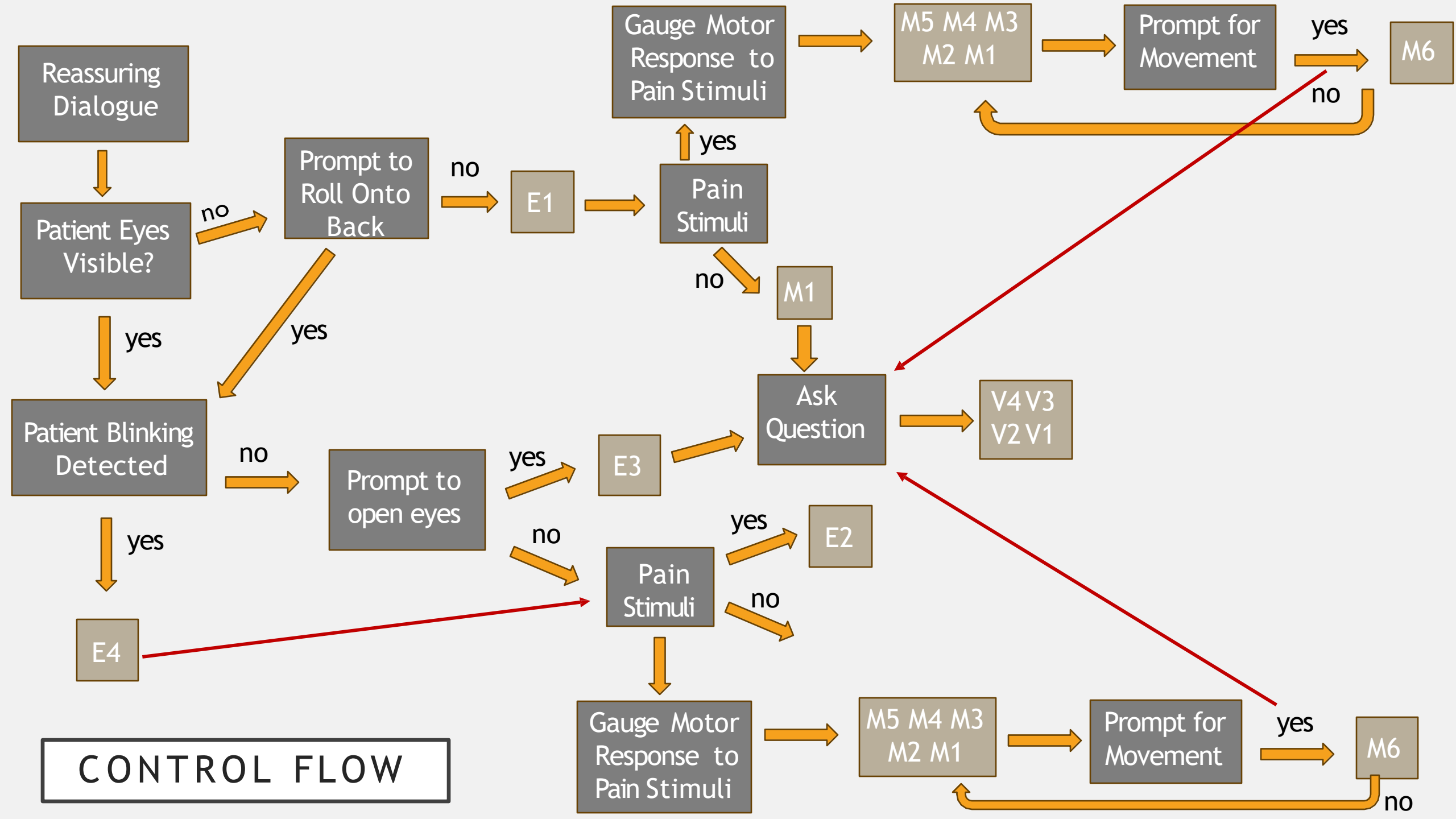
Process

- Under what circumstances/stimuli does patient move
- Patient asked to make a peace sign, victory sign, fist, etc
- External stimuli by laser and determine response
- Determine how the pose position markings change in response to stimuli

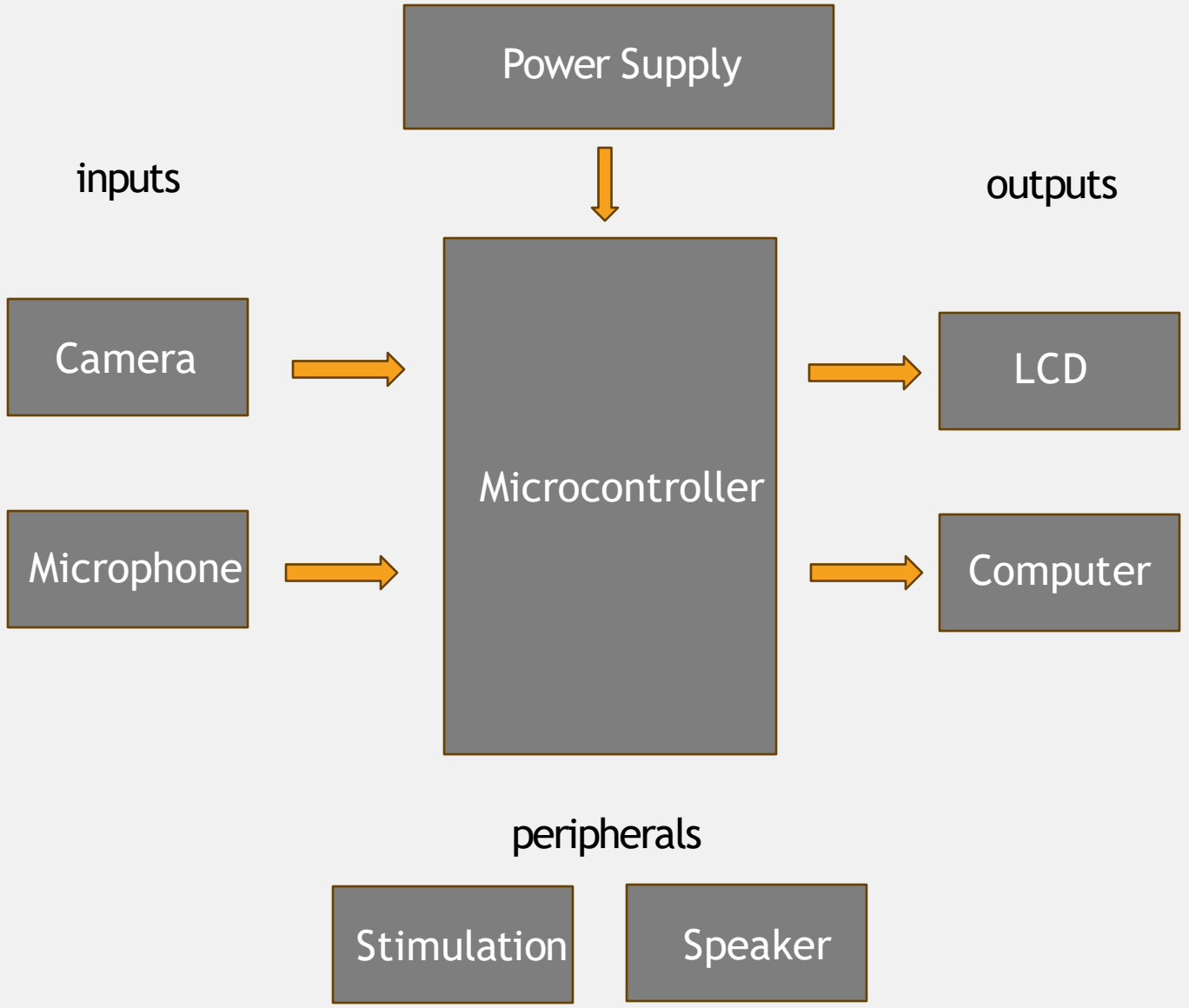
Teledyne Camera

Speaker

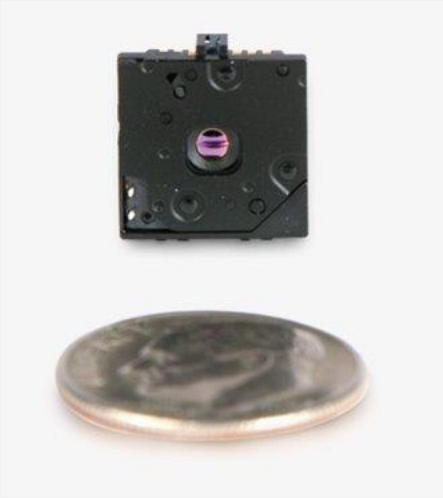
Laser


Reassuring Dialogue
Patient Eyes Visible?
no
Prompt to Roll Onto Back
no
E1
Gauge Motor Response to Pain Stimuli
M5 M4 M3 M2 M1
Prompt for Movement
yes
M6
no
yes
Pain Stimuli
no
M1
yes
yes
Patient Blinking Detected
no
Prompt to open eyes
yes
E3
Ask Question
V4 V3 V2 V1
yes
no
Pain Stimuli
yes
E2
no
E4
Gauge Motor Response to Pain Stimuli
M5 M4 M3 M2 M1
Prompt for Movement
yes
M6
no
CONTROL FLOW

BLOCK DIAGRAM



HARDWARE DEVICES



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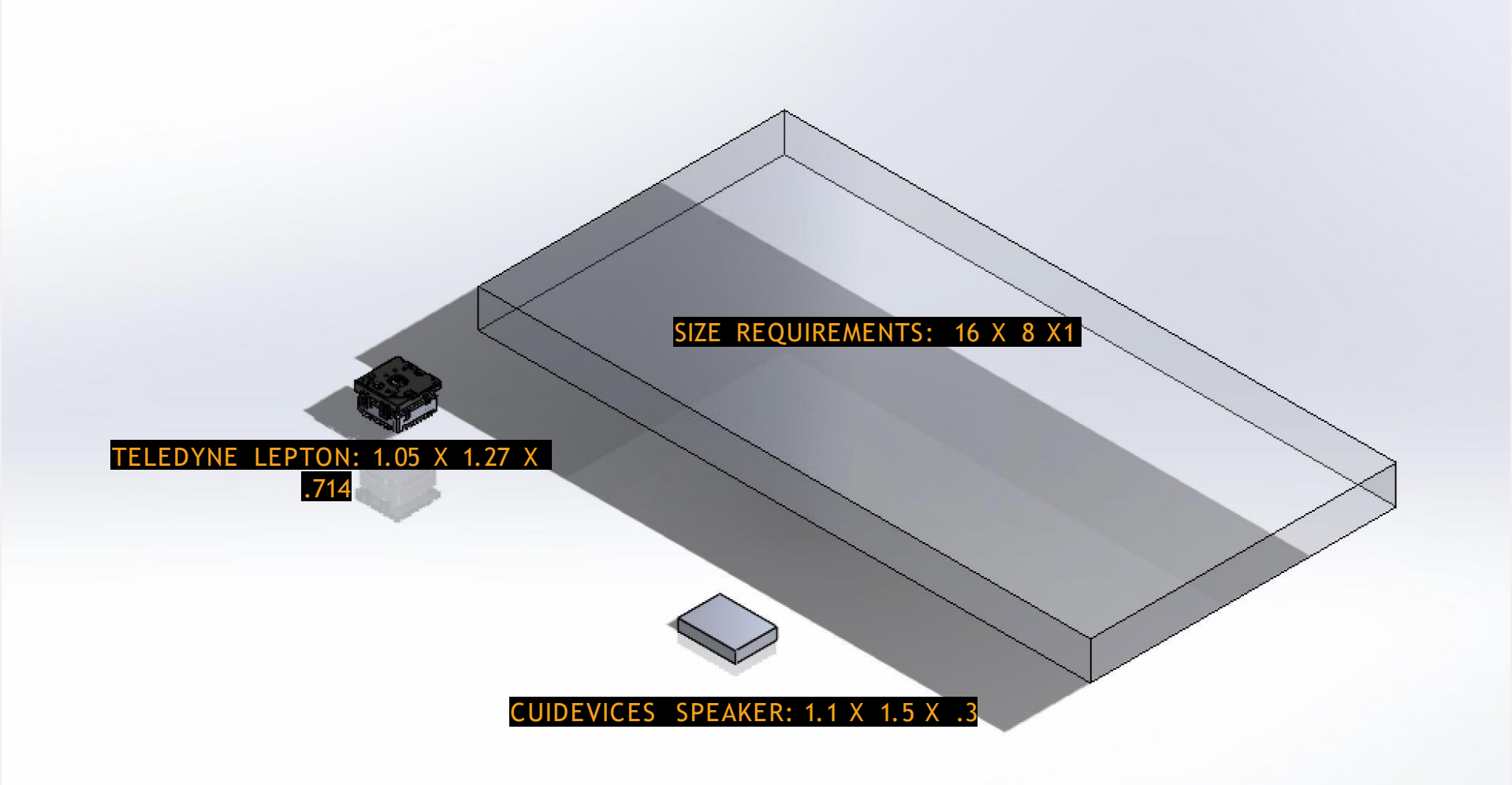
MODELING



ALL MEASUREMENTS IN CM

ROAD TO COMPLETION

- Create electronic schematic
- Model other chosen components
- Code NLP pipeline for Verbal Response and software for pose detection
- Choose battery/power source

X-FORCE
NATIONAL SECURITY INNOVATION NETWORK

Q&A

xforce@nsin.us | nsin.mil

PROPOSAL REQUESTED DOCUMENTS

GOAL

To design a smartphone sized drone attachment that can remotely assess a wounded Warfighter's state of consciousness on the battlefield as per the Glasgow Coma Scale.

GLASGOW COMA SCALE

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- Laser

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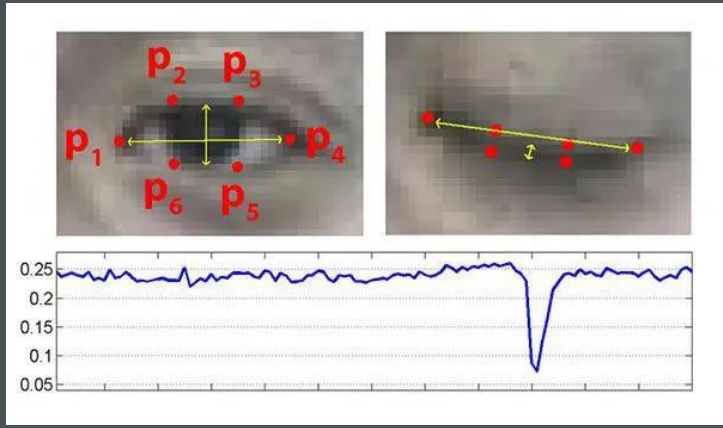

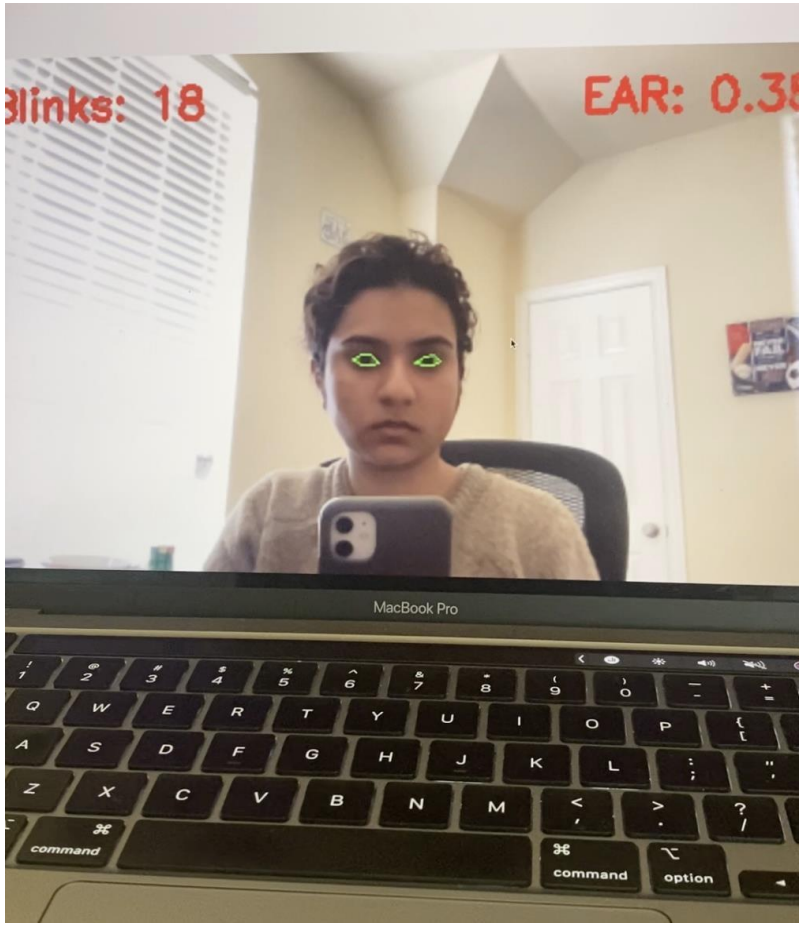

VERBAL RESPONSE

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Hardware

- Speaker
- Microphone

Process

- Ask patient question
- EX: Patient was asked what year it was. It is currently 1967 but the patient responded with "it it it is my time". Patient should be given score of 4

Speaker

NLP PIPELINE

- 3 Step Loop
- **SpeechifyText to Speech:** allows us to send a voice message to patient
- **PyAudio:** Python speech recognition module to transcribe speech to text
- **Open AI GPT-3.5:** allows for natural language processing of transcribed patient response to give verbal response score or answer any questions


```
Listening...
Finished recording.
2023
Answer: 5 = oriented
```

```
Listening...
Finished recording.
Speech recognition could not understand audio
Answer: 2 = incomprehensible
```

MOTOR RESPONSE

Glasgow Coma Scale

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- Speaker
- Laser

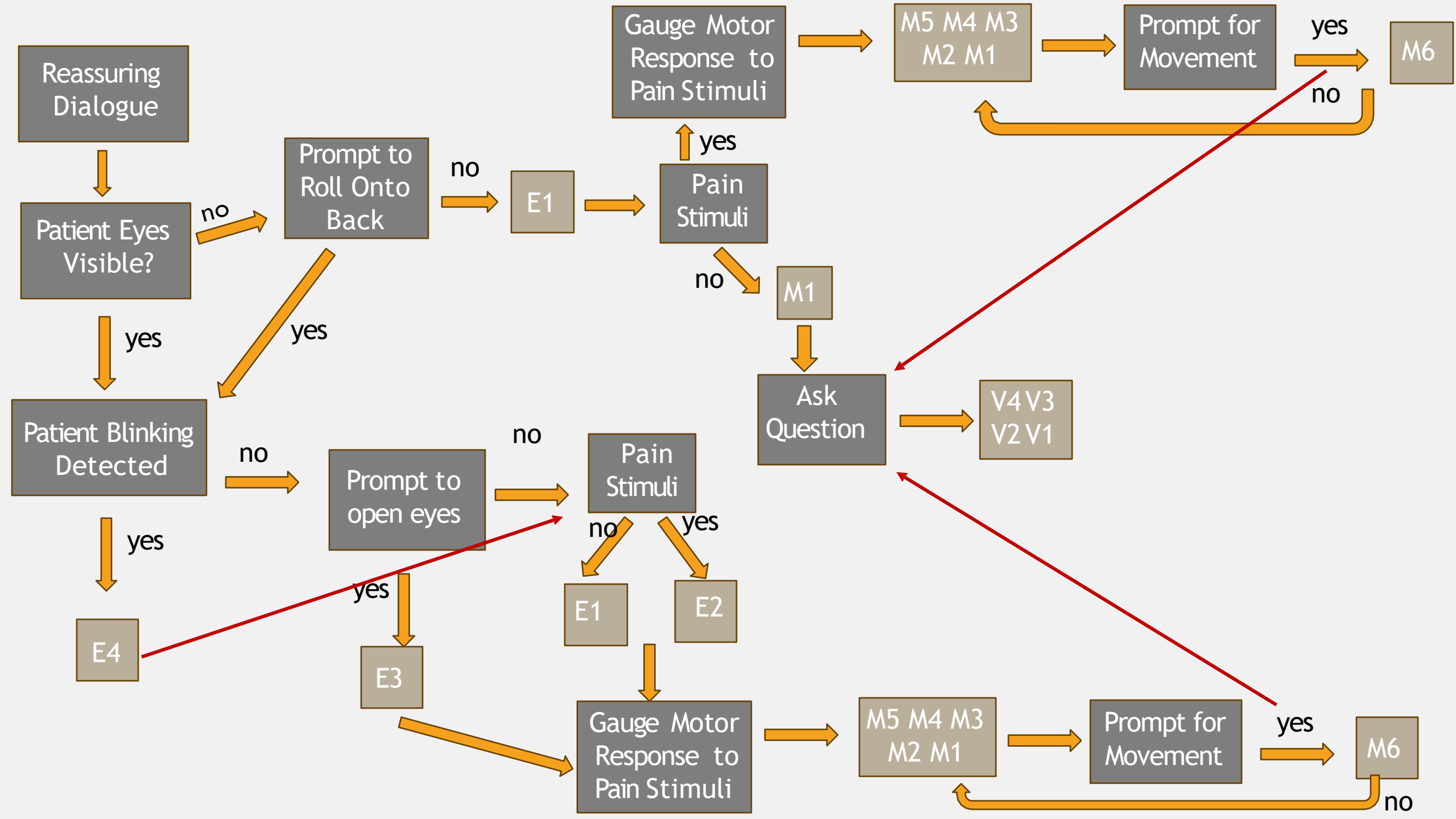
Process

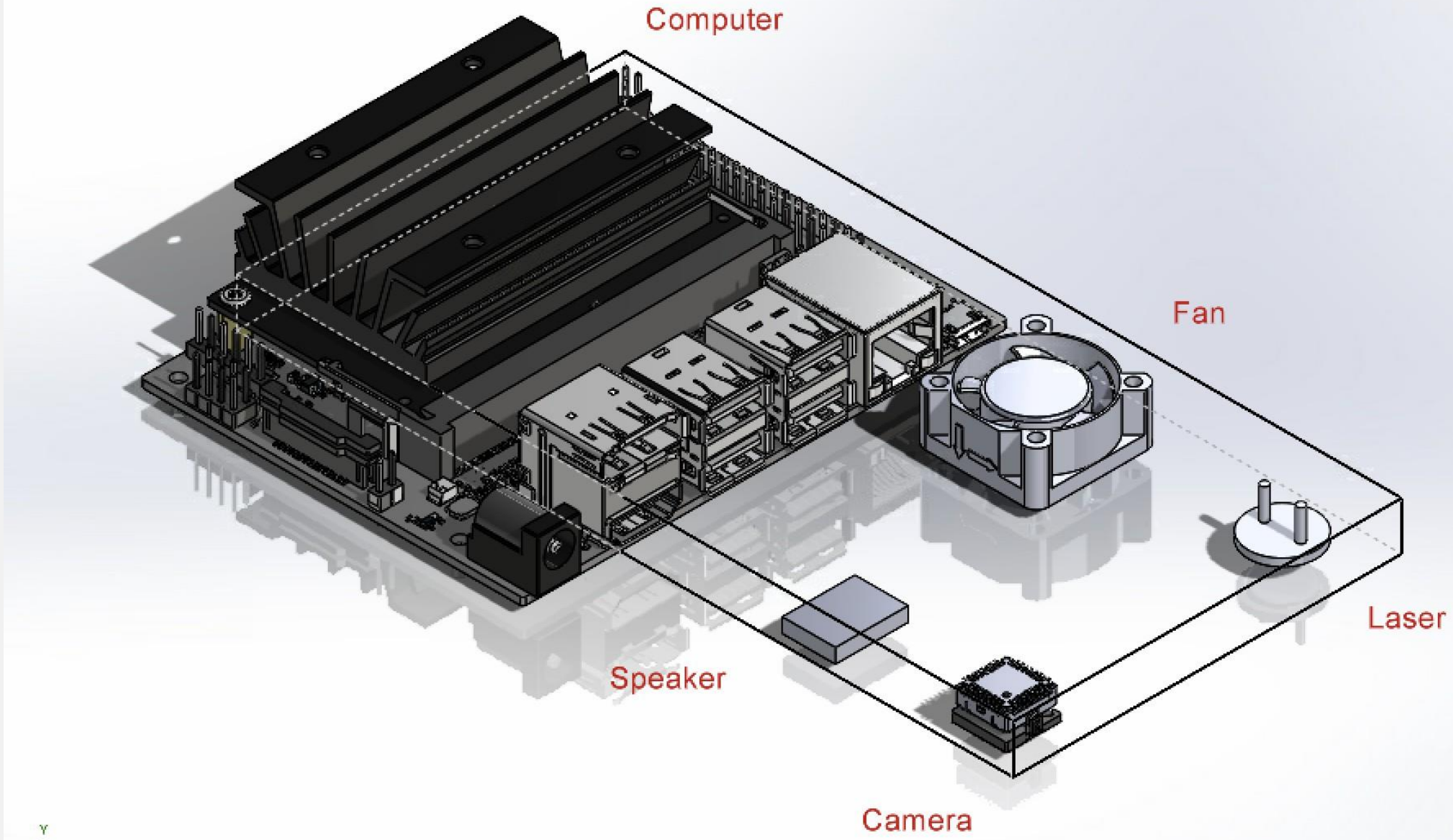
- Under what circumstances/stimuli does patient move
- Patient asked to make a peace sign, victory sign, fist, etc
- External stimuli by laser and determine response
- Determine how the pose position markings change in response to stimuli

Teledyne Camera

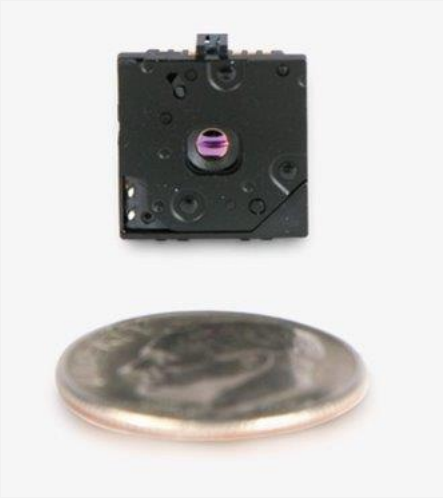
Speaker

Laser


Reassuring Dialogue
Patient Eyes Visible?
no
yes
Prompt to Roll Onto Back
no
yes
E1
Gauge Motor Response to Pain Stimuli
yes
Pain Stimuli
no
M1
M5 M4 M3 M2 M1
Prompt for Movement
yes
no
M6
Ask Question
V4 V3 V2 V1
Patient Blinking Detected
no
yes
Prompt to open eyes
no
Pain Stimuli
no
yes
E1
E2
E4
yes
E3
Gauge Motor Response to Pain Stimuli
M5 M4 M3 M2 M1
Prompt for Movement
yes
M6
no


Computer
Fan
Laser
Speaker
Camera
Y
X

HARDWARE DEVICES



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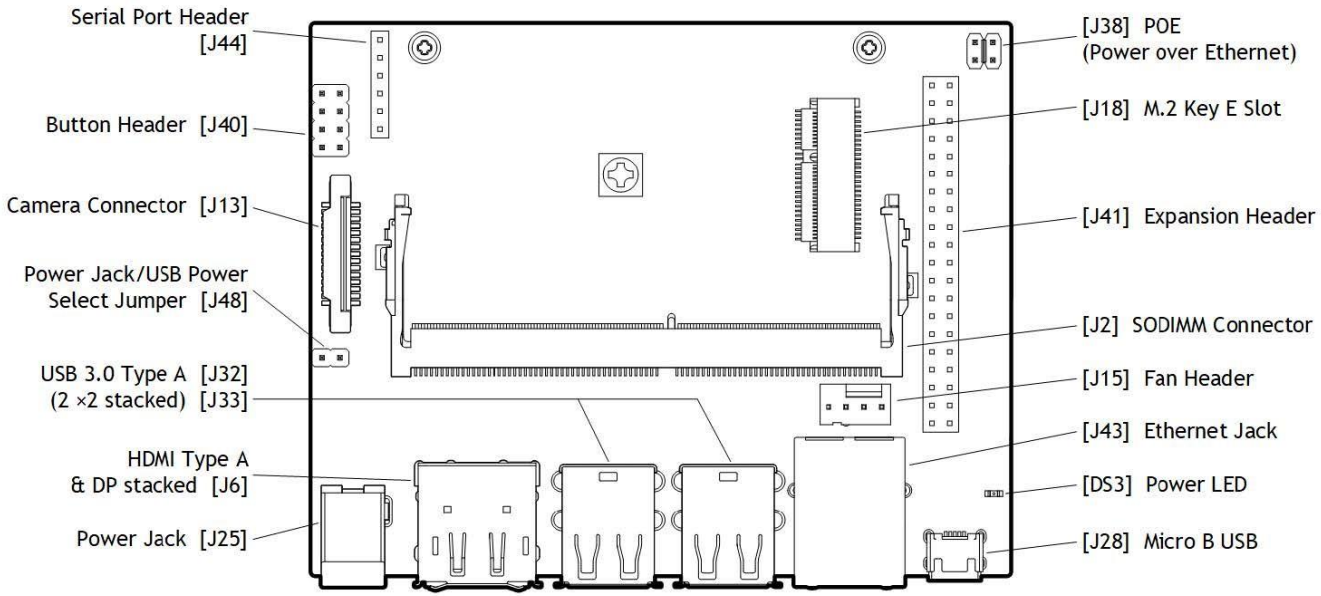
Other data	Wavelength of 1550nm	8.7 frames per second	94 db

WEEK 7

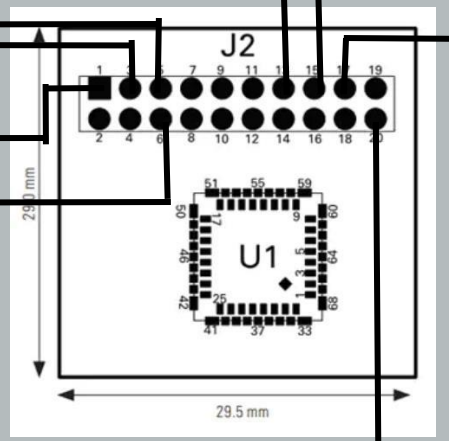
07/17/23 - 07/24/2023

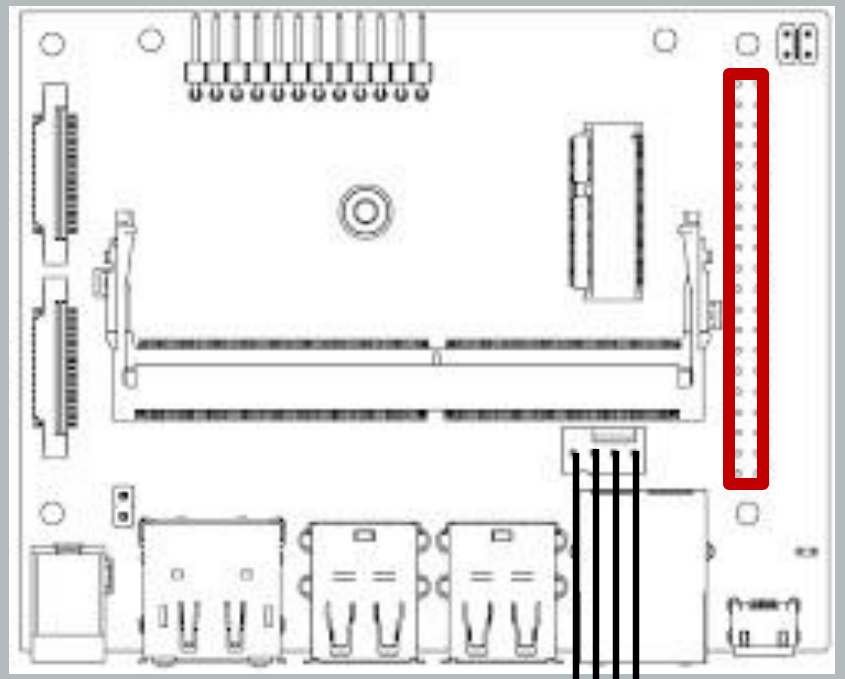


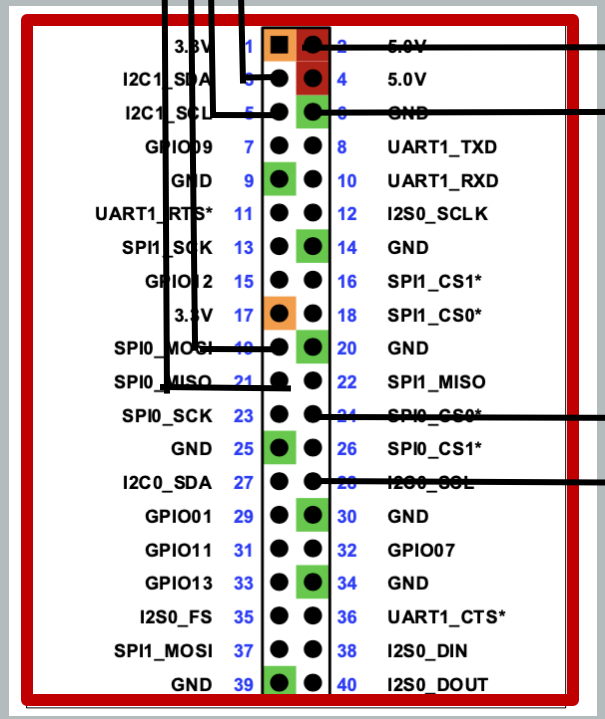
ELECTRONIC SCHEMATIC

ELECTRONIC SCHEMATIC

Camera







Laser Diode

USB C to barrel jack

Power Supply

Molex to USB

Speaker

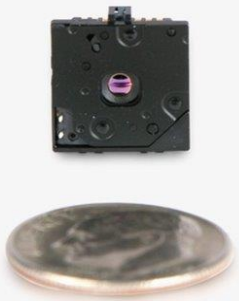
Fan

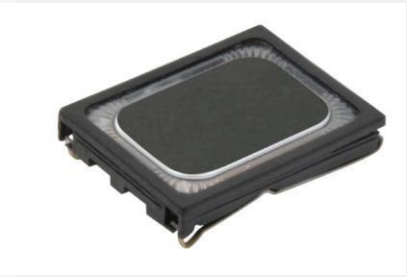
ELECTRONIC SCHEMATIC

- Computer:
  - Nvidia Jetson Nano Developer Kit ; will need to transition to Nvidia Jetson Nano Module for production
- Camera:
  - Lepton camera connection has been mapped to 40 pin expansion header
- Fan
  - Fan has been mapped to fan connector pins
- Speaker/Microphone
  - Nvidia Jetson Nano has no audio input/output, have to use an adapter
    - 3.5mm headphone jack and Pmod I2S2
    - Molex connector to USB adapter
    - Bluetooth
    - Consult additional companies for speaker

- Laser:
  - LED has been mapped to 40 pin expansion header ; optics will have to look into pulse rate, etc.
- Power supply
  - The only power supply that fits in the size constraints operates at 6700 mAh (we are running about 150mA at a time)
    - Would require an adapter barrel jack to USB C

HARDWARE COMPONENTS



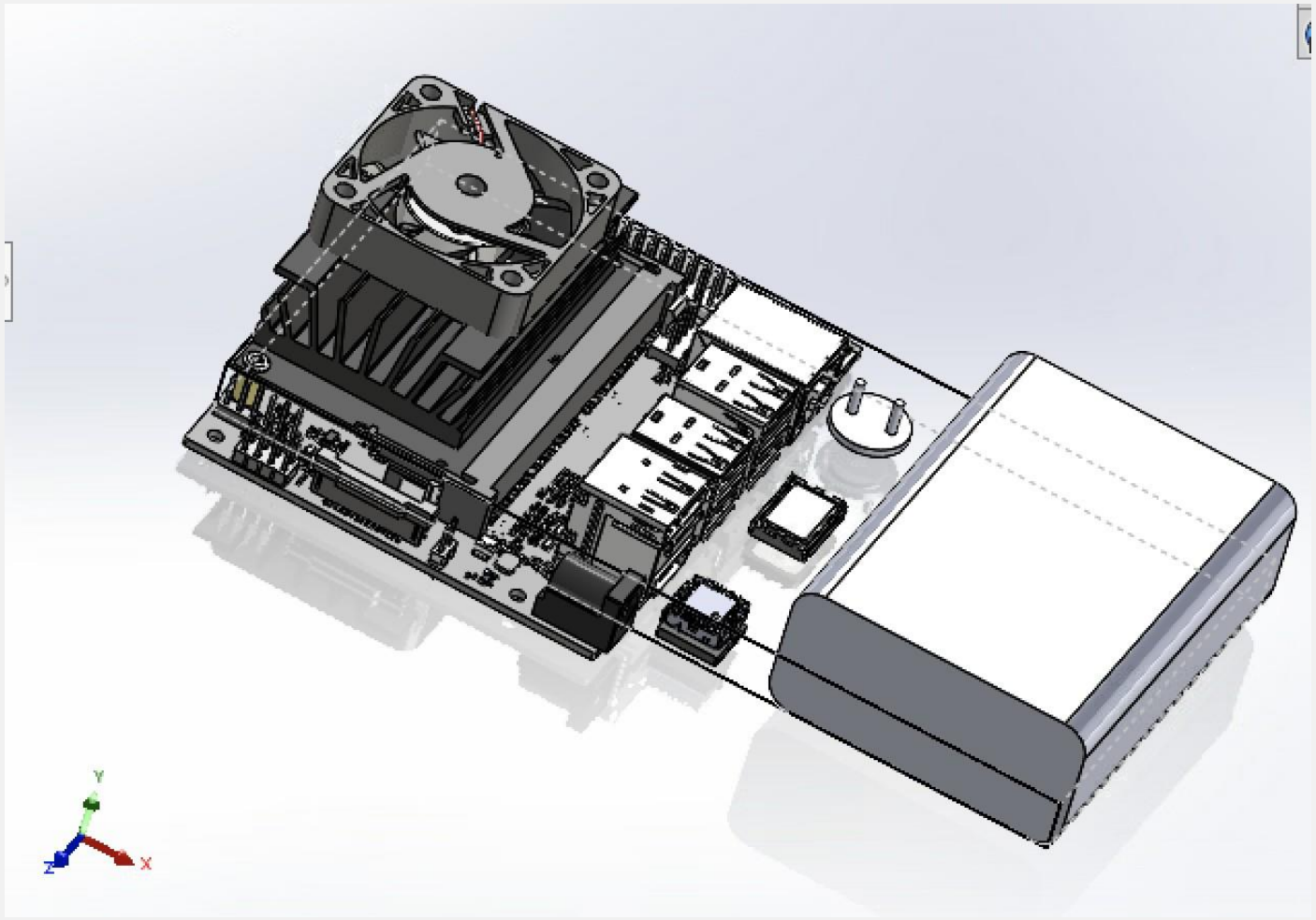


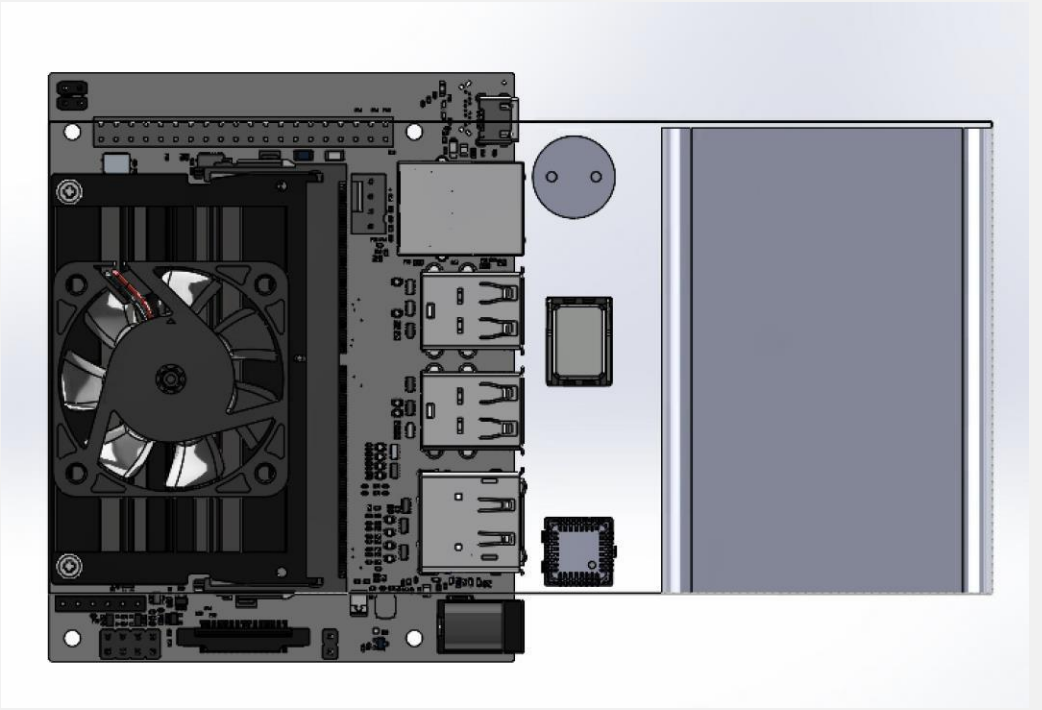
Name	Nvidia Jetson Nano Developer Kit	CUIDevices CFM-4010C-050-195	Teledyne FLIR Lepton	CUIDevices CMS-15113-078S-67	Laser
Dimensions (l x w x h cm)	10 x 7.9 x 2.8	4 x 4 x 1	1.05 x 1.27 x .714	1.1 x 1.5 x .3	A laser of this magnitude will likely require a heatsink (runs about 3cm in height at min). Looking into this for manufacturing purposes is likely for an optical engineer, but I can gather information
Voltage (V)	5	5	5	2.4	
Current (mA)	Max 6000	80	30	80	
Comments	switch to Jetson Nano Module when in production	suggested when operating above 80°C Must be mounted ABOVE heat sink on Jetson		Will require an adapter	

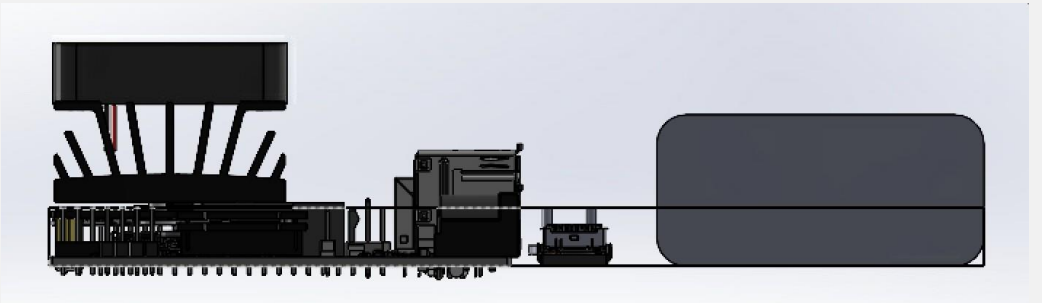
HARDWARE COMPONENTS (POWER SUPPLY)

We are running 200mA at a time

Name	Rechargeable flat Lithium ion battery pack	Rechargeable Lithium ion battery pack	Power bank (Zendure SuperMini 10000mAh)
Dimensions (l x w x h cm)	6 x 5 x 1.9	7 x 3.6 x 3.6	7.9 x 5.6 x 2.6
Voltage (V)	7.4	7.4	5
Current (mAh)	5000	5500	4000
Comments	Need to find American manufactured version		


Y
X
Z





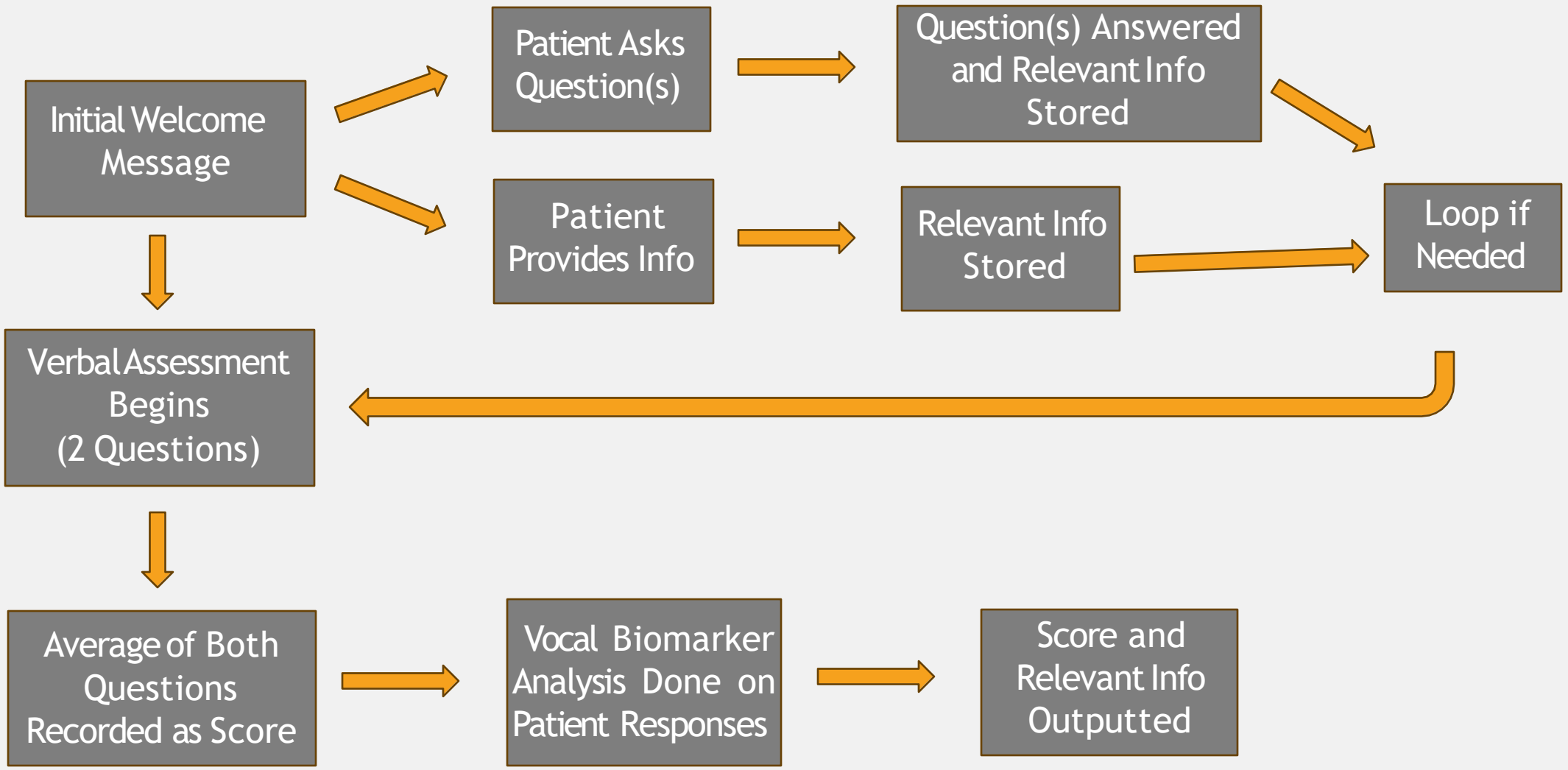
QUESTIONS AND FUTURE CONSIDERATIONS

- What information should be gathered about the laser?
- What level of detail should the final electronic schematic contain?
- Are adapters O K to include or should we suggest soldering/cutting wires to obtain necessary connections?
- We are focusing on the Jetson Nano Developer Board, should we do preliminary research on the Jetson Nano Module for production purposes?

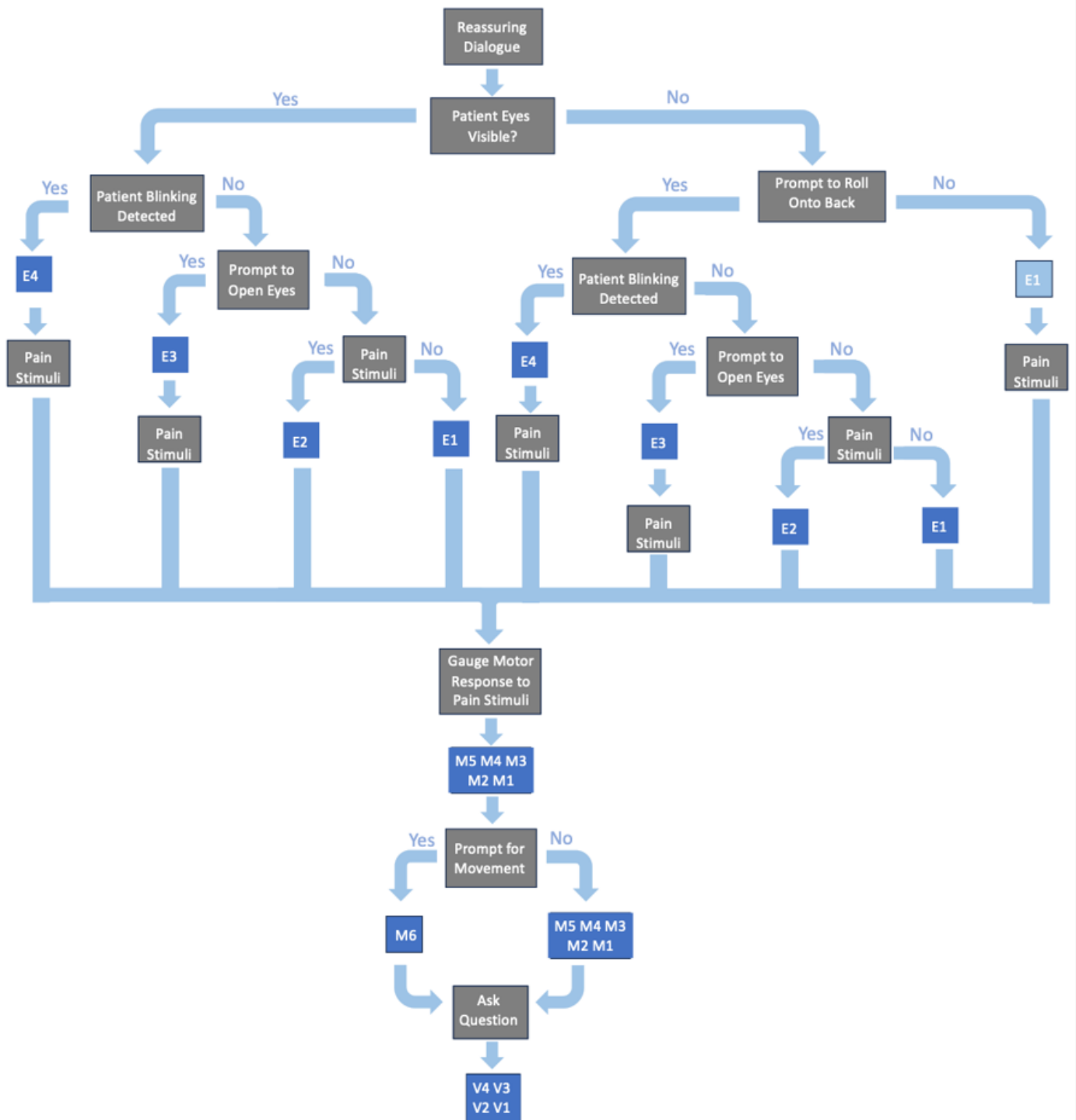
WEEK 8

07/24/23 - 07/31/2023

VERBAL RESPONSE FLOW



CONTROL FLOW



MOTOR RESPONSE

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- 6: Obeys commands for movement 6 points
- 5: Purposeful movement to painful stimulus
- 4: Withdraws in response to pain
- 3: Flexion in response to pain (decorticate posturing)
- 2: Extension response in response to pain (decerebrate posturing)
- 1: No response

Software

- Pose Detection Software/Models
  - https://developers.google.com/ml-kit/vision/pose-detection
  - https://github.com/CMU-Perceptual-Computing-Lab/openpose

Hardware

- Camera
- Speaker
- Laser

Process

- Under what circumstances/stimuli does patient move
- Patient asked to make a peace sign, victory sign, fist, etc
- External stimuli by laser and determine response
- Determine how the pose position markings change in response to stimuli

Teledyne Camera

Speaker

Laser

MOTOR RESPONSE

```
distance_right = calculate_distance(right_shoulder, right_wrist)
distance_left = calculate_distance(left_shoulder, left_wrist)

# Evaluate motor response based on the distance thresholds
if distance_right <= 60 and distance_left <= 60:
    return 6  # Obeys commands for movement (6 points)
elif distance_right <= 100 and distance_left <= 100:
    return 5  # Purposeful movement to painful stimulus (5 points)
elif distance_right <= 150 and distance_left <= 150:
    return 4  # Withdraws in response to pain (4 points)
elif distance_right <= 200 and distance_left <= 200:
    return 3  # Flexion in response to pain (decorticate posturing) (3 points)
elif distance_right <= 250 and distance_left <= 250:
    return 2  # Extension response in response to pain (decerebrate posturing) (2 points)
else:
    return 1  # No response (1 point)
```

- 3 Step
- **Python OpenCV:** identifies landmarks on body via camera and Mediapipe
- **Pose Detection:** landmarks marked and stored along with x,y coordinates
- **Score Calculation:** score calculated based on coordinates and outputted to medic

WEEK 9

07/31/23 - 08/07/23

VOCAL BIOMARKERS

Emotion Assessment:

- Pitch and Tone: High-pitched voices indicate excitement or stress, while low-pitched voices signal sadness or calmness
- Speech Rate: Rapid speech suggest excitement, while slower speech could indicate sadness or relaxation.
- Prosody: Rhythm, intonation, and stress patterns in speech

Stress Assessment:

- Vocal Quality: Hoarseness, tension, or even trembling in the voice.
- Pitch Variability: High stress levels can lead to reduced pitch variability, resulting in a monotone or tense voice
- Speech Rate: Stress might cause faster speech due to increased arousal, or it could cause slower speech as the individual carefully chooses their words.

Fatigue Assessment:

- Voice Fatigue: Tired, strained, or weak voice
- Pitch Breaks: Voice cracks or jumps unexpectedly due to vocal cord strain
- Breathiness: Voice sound breathy, indicating that the person is struggling to control their airflow

MAKER PROGRAM (BY NSIN)

- Maker program offers prototyping assistance to solutions coming out of other NSIN programs at no cost to the sponsor organization
- We met with Jacob Wisenbaker, the Program Manager for Maker
  - He expressed interest in our solution and ease of integration into the Maker program
- After the X-Force fellowship is complete, you can expect communication from individuals at Maker/X-Force to see if USARIEM would be interested in this program

WEEK 10: DEMO DAY

08/08/23 - 08/11/23

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NATIONAL SECURITY INNOVATION NETWORK

Buddy Care Mate

United States Army Research Institute of Environmental Medicine

Alexa Plotkin & Shrika Eddula
Dr. Gary Zientara, Ph.D.

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Goal

Design a smartphone sized drone attachment that can remotely assess a wounded Warfighter's state of consciousness on the battlefield as per the Glasgow Coma. The assessments are classified into eye, verbal, and motor response.

Eye Response

Glasgow Coma Scale

- **4**: Spontaneous--open with blinking at baseline
- **3**: To verbal stimuli, command, speech
- **2**: To pain only (not applied to face)
- **1**: No response

Process

- Under what circumstances/stimuli does patient open their eyes
- Use traditional eye tracking software to test for eyes opening and blinking
- Include a speaker to instruct patient to open their eyes
- Include a laser to simulate a pain response


Teledyne Camera


Speaker


Laser

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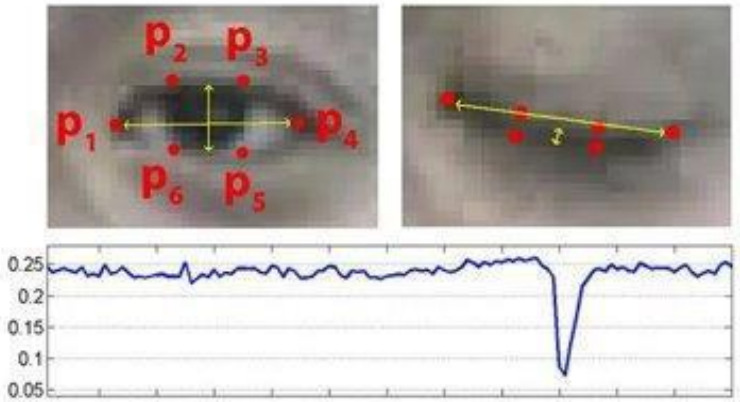
Eye Response Software

- 6 facial landmarks for each eye
- Built using mathematical measurements for eye aspect ratio calculated using distances between landmarks
- Eye aspect ratio will go down with blink
- Platform: Python OpenCV
- Can use threading to work with lower fps




Blinks: 7
EYE: 0.41

Verbal Response

Glasgow Coma Scale

- 5: Oriented
- 4: Confused conversation, but able to answer questions
- 3: Inappropriate words
- 2: Incomprehensible speech
- 1: No response

Process

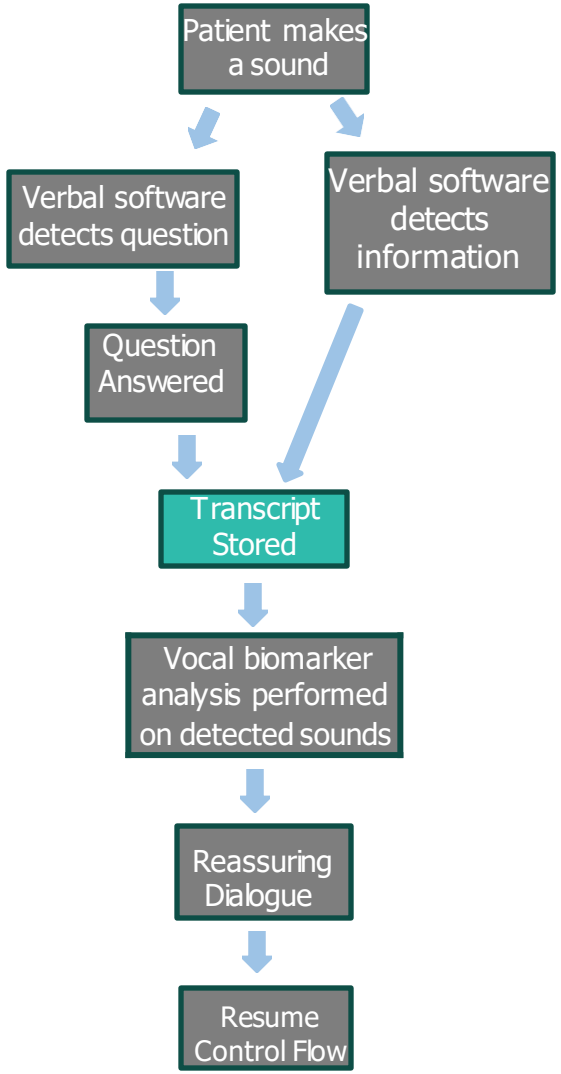
- Ask patient question
- EX: Patient was asked what year it was. It is currently 1967 but the patient responded with "it it it is my time". Patient should be given score of 4

Speaker

Verbal Response Software

3 Step Loop

- **Google Text-to-Speech (gTTS)**: voice message to patient
- **PyAudio & Google Speech Recognition**: transcribe speech to text in real time
- **Open AI GPT-3.5 Turbo**: NLP of patient response, give verbal response score or answer any questions



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```
(buddymate) shrika@Shrikas-MBP BuddyMate % python verbal_response.py
```

Motor Response

Glasgow Coma Scale

- 6: Obeys commands for movement 6 points
- 5: Purposeful movement to painful stimulus
- 4: Withdraws in response to pain
- 3: Flexion in response to pain (decorticate posturing)
- 2: Extension response in response to pain (decerebrate posturing)
- 1: No response

Process

- Under what circumstances/stimuli does patient move
- Patient asked to make a peace sign, victory sign, fist, etc
- External stimuli by laser and determine response
- Determine how the pose position markings change in response to stimuli

Teledyne Camera

Speaker

Laser

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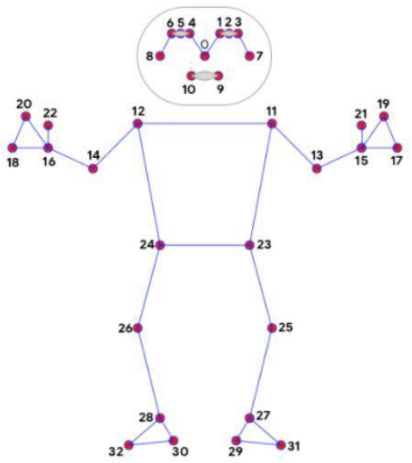
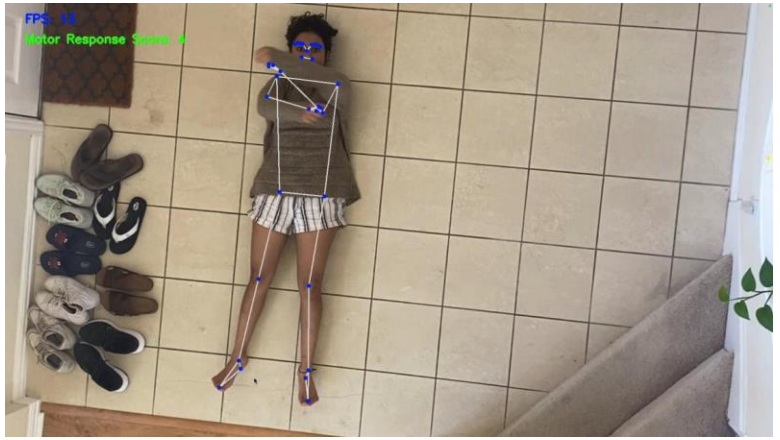
Motor Response Software

- **Python OpenCV**: identifies landmarks on body via camera and Mediapipe
- **Pose Detection**: landmarks marked and stored along with x,y coordinates
- **Score Calculation**: score calculated based on coordinates and outputted



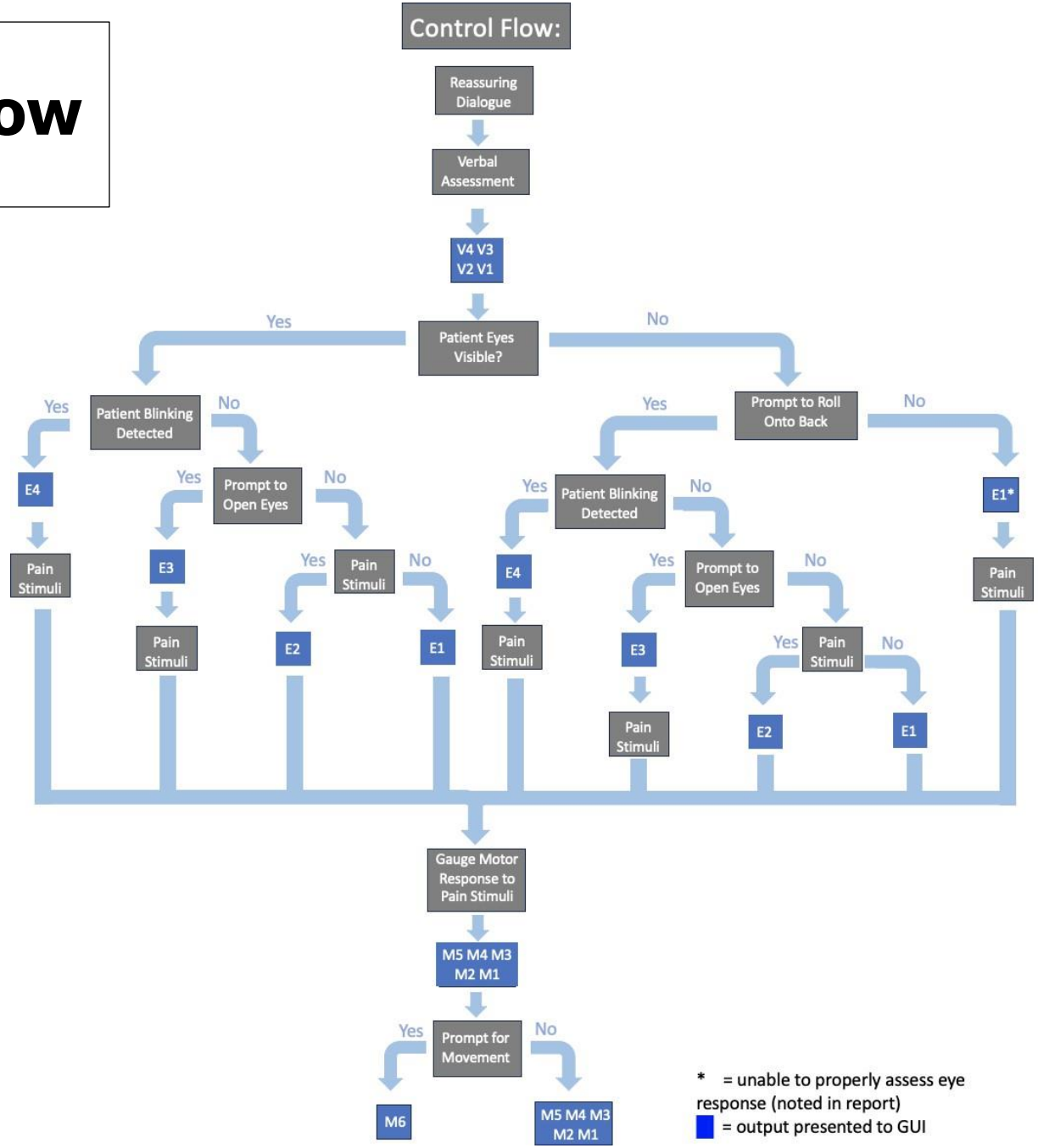
0. nose
1. left_eye_inner
2. left_eye
3. left_eye_outer
4. right_eye_inner
5. right_eye
6. right_eye_outer
7. left_ear
8. right_ear
9. mouth_left
10. mouth_right
11. left_shoulder
12. right_shoulder
13. left_elbow
14. right_elbow
15. left_wrist
16. right_wrist
17. left_pinky
18. right_pinky
19. left_index
20. right_index
21. left_thumb
22. right_thumb
23. left_hip
24. right_hip
25. left_knee
26. right_knee
27. left_ankle
28. right_ankle
29. left_heel
30. right_heel
31. left_foot_index
32. right_foot_index



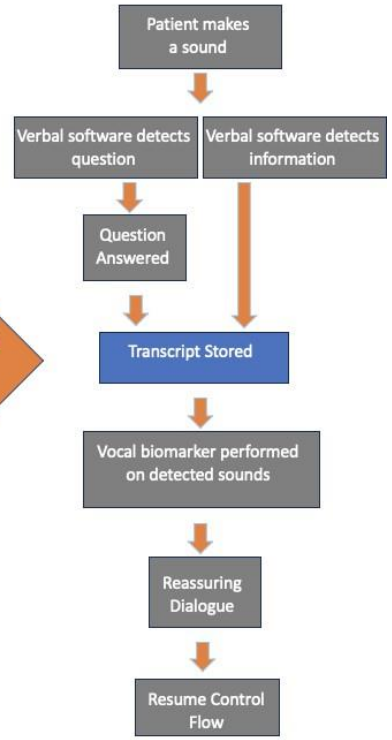

FPS: 23
Motor Response Score: 1


FPS: 11
Motor Response Score: 1

Control Flow



If patient makes sound at any point



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Graphical User Interface (GUI)

Eye Response: 2

Notable Info

- Inability for the patient to assume supine position)
- Irregular blink pattern

Motor Response: ?

Notable Info

- Body position: supine, prone, etc.
- Missing limbs
- Muscle spasms
- Surrounding environment

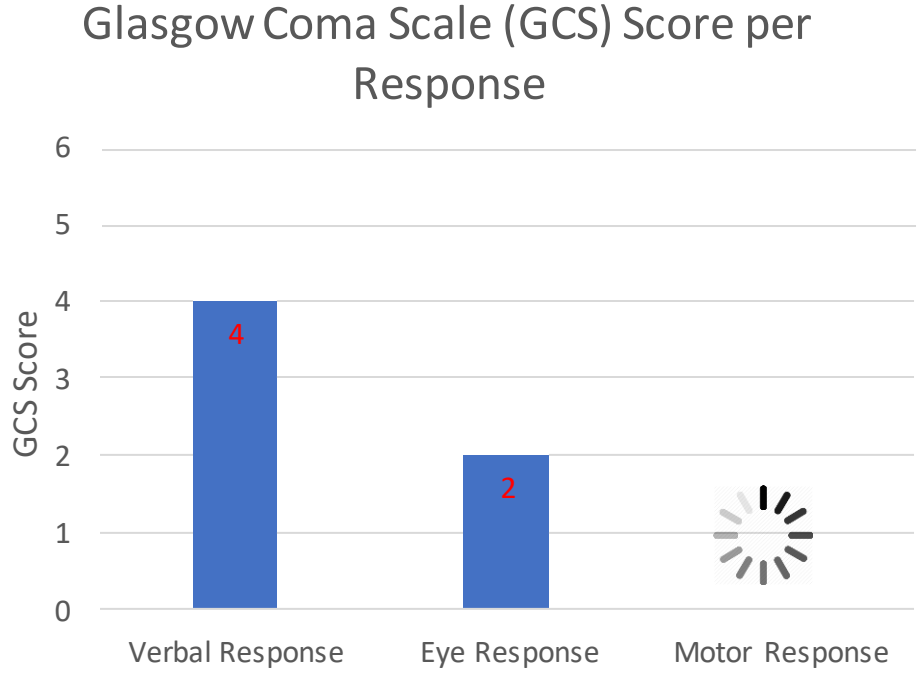
Assessment is 60% complete

Verbal Response: 5

```
(buddymate) shrika@Shrikas-MBP BuddyMate % python ver
Listening...
Finished recording.
who are you
(1, "We are attempting to remotely assess your condit
r response. This device is part of a UAV system sent
Listening...
Finished recording.
2023
Answer: The patient is:
5: Oriented. A response with 2023 in it indicated the
Listening...
Finished recording.
Speech recognition could not understand audio
Answer: Based on the information provided, the patien
" does not provide any indication of the patient's or
-----------------------------------
-----------TEST COMPLETE-----------
{'questions': ['who are you']}
(buddymate) shrika@Shrikas-MBP BuddyMate %
```

Notable Info

- Vocal biomarker analysis
- Background noise
- Relevant information patient provides
- Conversation or questions



Eye Response: 2

Notable Info

- Inability for the patient to assume supine position)
- Irregular blink pattern

Motor Response: ?

Notable Info

- Body position: supine, prone, etc.
- Missing limbs
- Muscle spasms
- Surrounding environment

Assessment is 100% complete

Verbal Response: 5

```
(buddymate) shrika@Shrikas-MBP BuddyMate % python ver
Listening...
Finished recording.
who are you
(1, "We are attempting to remotely assess your condit
r response. This device is part of a UAV system sent
Listening...
Finished recording.
2023
Answer: The patient is:
5: Oriented. A response with 2023 in it indicated the
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Answer: Based on the information provided, the patien
" does not provide any indication of the patient's or
----------------------------------
-----------TEST COMPLETE-----------
{'questions': ['who are you']}
(buddymate) shrika@Shrikas-MBP BuddyMate %
```
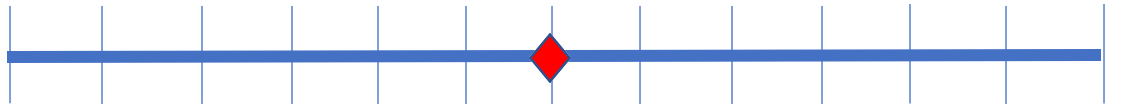

Notable Info

- Vocal biomarker analysis
- Background noise
- Relevant information patient provides
- Conversation or questions

Glasgow Coma Scale (GCS) Score



Patient's brain injury is Moderate

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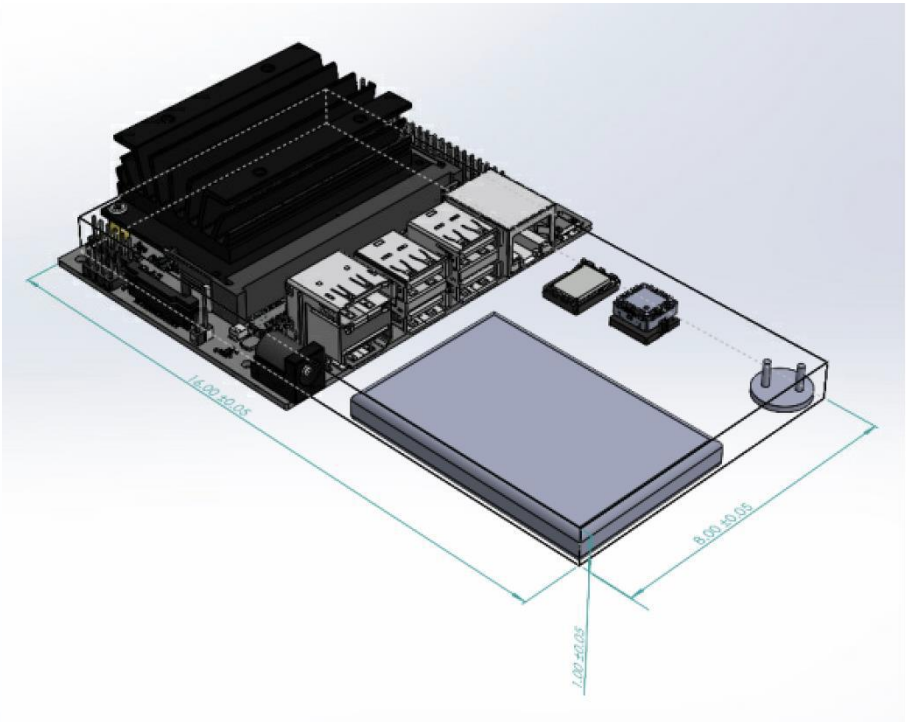
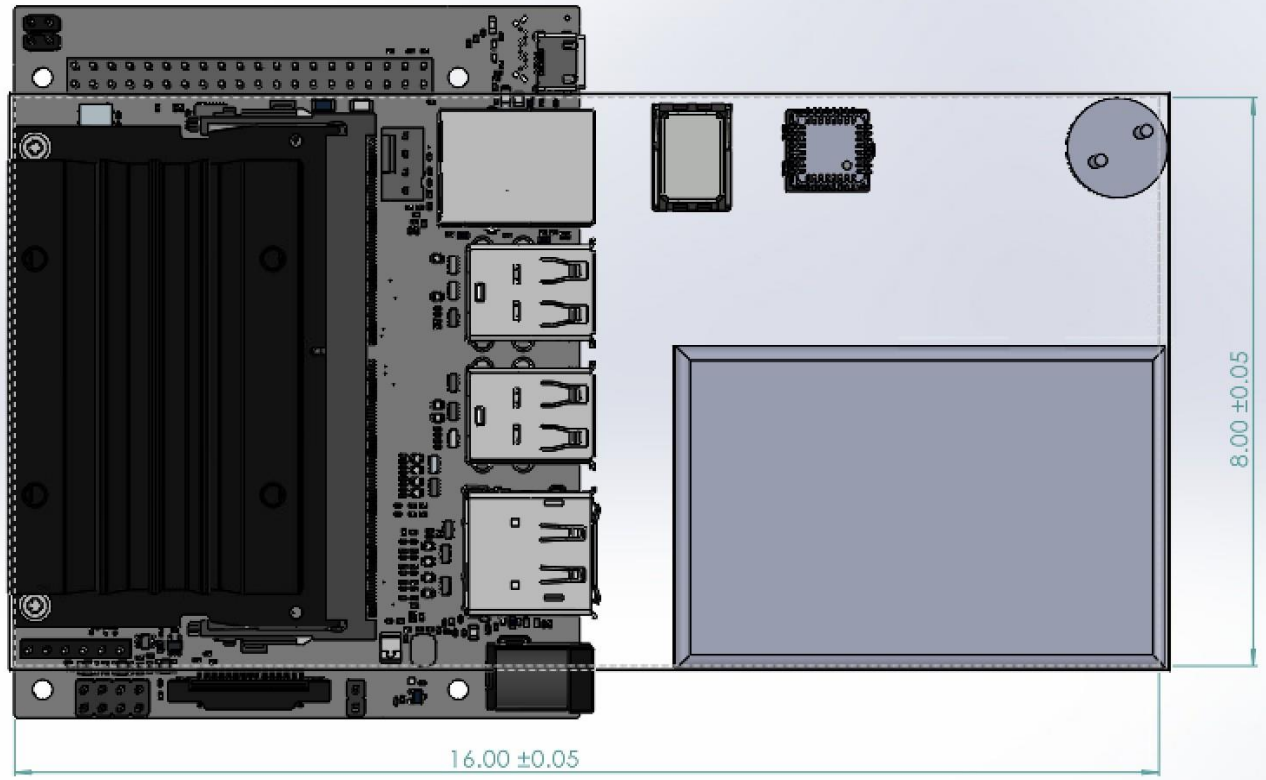
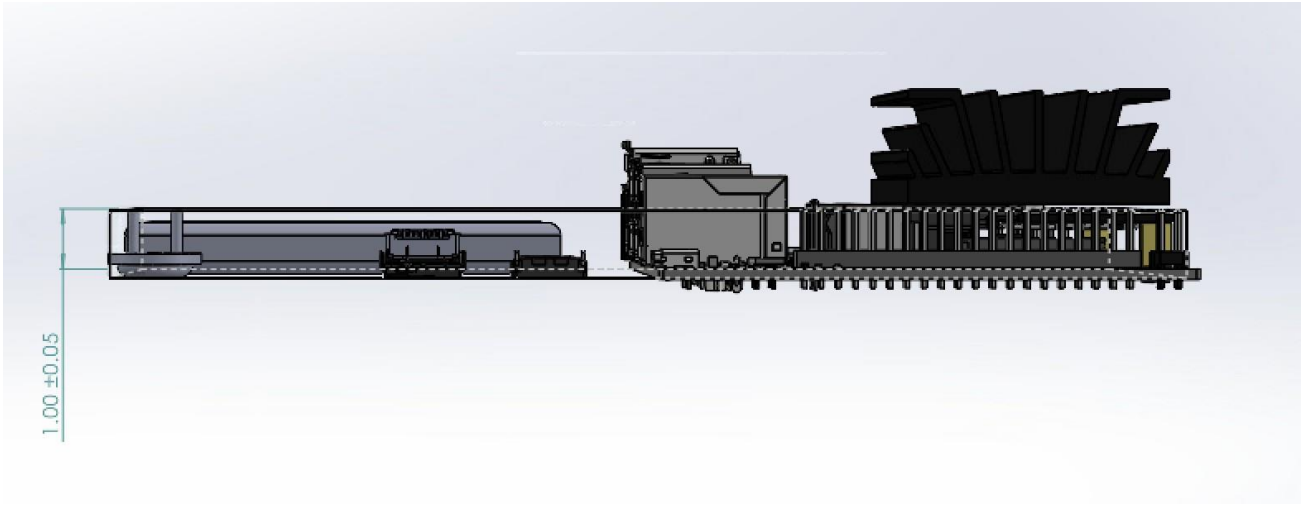
CAD Model







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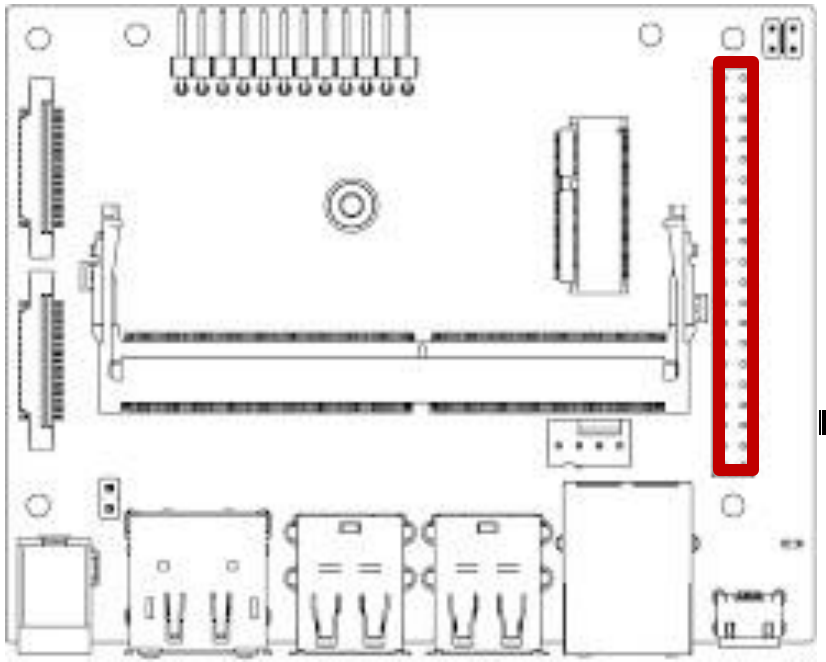
Electronic Schematic

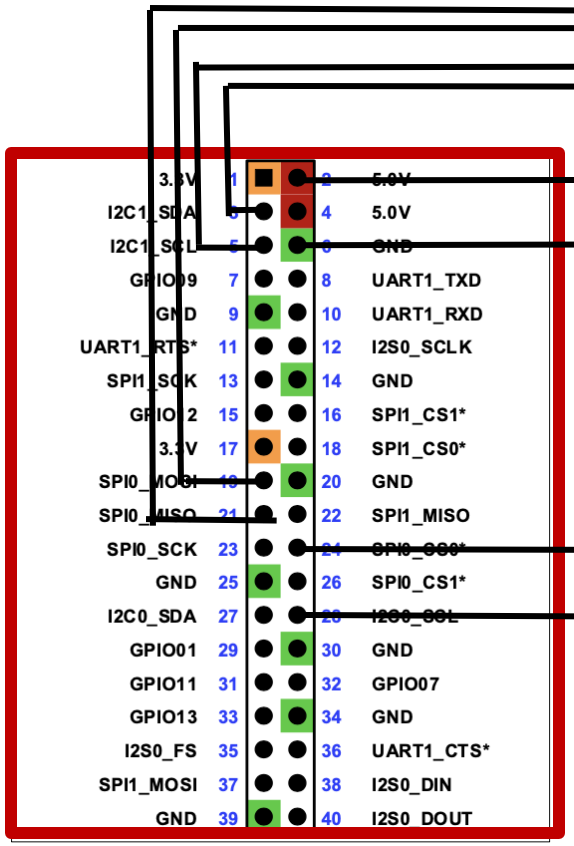


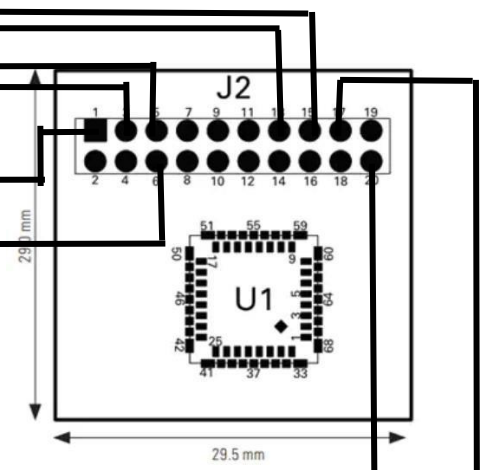
USB C to barrel jack

Molex to USB

Power Supply

Speaker





Camera

Laser Diode

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Future

- Part of a remote triage system of drone attachments
- Portions of our report have been sent to be approved for future development
- Looking into the Maker program by NSIN

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Q&A

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